Visualizing energy consumption activities as a tool for making everyday life more sustainable

Kajsa Ellegård and Jenny Palm

Original Publication:

Kajsa Ellegård and Jenny Palm, Visualizing energy consumption activities as a tool for making everyday life more sustainable, 2011, Applied Energy, (88), 5, 1920-1926.
http://dx.doi.org/10.1016/j.apenergy.2010.11.019

Visualizing Energy Consumption Activities as a Tool for Making Everyday Life More Sustainable

Kajsa Ellegård* and Jenny Palm

Department of Thematic Studies—Technology and Social Change, Linköping University, 581 83 Linköping, Sweden

E-mail addresses: kajsa.ellegard@liu.se (K. Ellegård); jenny.palm@liu.se (J. Palm)

*Corresponding author: kajsa.ellegard@liu.se; Tel.: +46-13-285836; Fax: +46-13-284461.

Abstract: The need to analyze and understand energy consumption in relation to households' activity patterns is vital for developing policy means that contribute to an energy efficient life and what people would deem as a "good" everyday life. To do this we need to learn more about how energy use is a part of everyday life; this article contributes to that objective. We use the time-geographic diary approach together with interviews to analyze everyday life as a totality. From household members' time diaries, we can analyze and learn about when, where, and what energy-related activities occur in a household context and by whom (and in what social context) they are performed. We discuss the importance of relating information and feedback to households' everyday activities, in order to make it relevant to households. Through our method we discover and visualize activity patterns in a household during a given period. The method is also useful to households as a reflective tool when discussing families' daily lives in relation to energy consumption. The method gives direct feedback to households and the information is relevant since it emanates from their own reported activities.

Keywords: energy consumption; household; time diary; policy; information; feedback; activity pattern; everyday life; time-geography; visualization

---

1. Introduction

The sustainability debate has become a climate debate, within which reducing CO_2 emissions is the highest priority. The International Energy Agency (IEA) has stated that current trends in energy supply and consumption are patently unsustainable and must be altered. In its efforts to stabilize and reduce emissions, the EU Commission has prioritized energy issues and set the so-called 20/20/20 goals: to obtain 20 percent of its overall energy mix from renewable sources, to reduce total primary energy consumption by 20 percent, and to cut greenhouse gas emissions by at least 20 percent, all by 2020 [1].

Policy aimed at promoting energy efficiency in the household sector must relate to and rely on individuals' daily choices and household routines—what they do in their everyday lives. Hence, individuals' values and knowledge about how their everyday activities influence energy use are important for the development of an efficient and ecologically sustainable energy system. Peoples' understanding of their responsibilities and willingness to shoulder them are seen as key factors in creating a sustainable society [2].

We will examine energy consumption in the household sector and discuss energy use from a household-level perspective. This represents a shift away from the conventional focus of energy supply in the household sector towards one of energy use in everyday life. This shift is urgent since deeper knowledge is needed on the part of households, policy-makers, housing companies and researchers about how energy makes necessary functions in peoples' daily lives easier. It is important to develop new paths to smart and climate-friendly energy use that continue to facilitate peoples' everyday lives. In this article, basic functions of everyday life are placed in focus and the energy needed to discharge them is discussed. According to Annika Carlsson-Kanyama and Anna-Lisa Lindén [3], the functions of a good life are: a comfortable indoor climate, convenient hot water, a clean home, clean clothes and body, food and drink, opportunities to move from place to place, and information, communication and entertainment. We will discuss how to analyze energy use in households' activity patterns related to such functions.

The dominant methods for encouraging people to change their energy consumption behavior have long been information campaigns, the energy labeling of white goods, energy advice, and so on. The results achieved so far, however, have been insufficient [4,5]. Although at a rhetorical level people are aware of the importance of using energy efficiently, concrete action is lacking—household energy use has not decreased. This can be partially explained by people not relating the satisfaction of their daily needs to the energy demanded by the (increasing) stock of appliances in their homes. For example, there has been a rapid rise in demand for novel electronic devices (e.g., information and communication technologies and other electronic devices), a high turnover of white goods due to fashion trends, more use of lighting in architecture, and the spread of specialized and individualized appliances. In addition, the demand for air conditioning has increased while considerable energy is still needed for heating [6,7].

Another explanation of the non-decreasing energy demand in the household sector is that decreased energy use is often rhetorically connected with changing peoples' current lifestyles to ones that are less comfortable and convenient. But is it so? How can we know that a reduced energy use in a household does not rather *contribute* to the good life of its members? To draw any conclusions about how energy conservation will affect a household we must know more about how energy use contributes to everyday life today, which will be in focus in this article.

The purpose of this article is to discuss the importance of visualization and how to visualize households' members' energy consumption when striving for sustainability. To gain new knowledge in this area we need to know how life is lived today, not just in specific households but also in households at the aggregate level.

2. The Household Context

The housing sector accounts for approximately one-third of Sweden's total energy use, with the use phase accounting for approximately 85 percent of a building's total energy use [8]. From 1970 to the mid-1980s, housing sector energy use declined from 350 kWh/m^2 to 180 kWh/m^2. There are material constraints setting the outer limit for reducing energy use in the housing sector. Within these limits, the actions and choices of householders as inhabitants are crucial, and reductions were observed in both existing and new housing stock and applied to detached houses as well as apartment buildings. In the mid-1980s, however, this decline ceased [9]. Most energy use in the housing sector is used for regulating indoor climate and for heating water [10]. Household energy use for heating/cooling and running appliances is important for households, but it is equally important for municipalities and the enterprises developing and creating energy systems. Building codes and house/apartment layout and equipment (e.g., HVAC and appliances) exemplify material constraints that frame household energy use. There are opportunities to influence energy use within this framework, and this task mainly concerns households and local householders. This framework also delimits the scope of this article; now we approach the “opportunity space” within which households may influence their own energy use.

Since people spend most of their time at home, the physical context in which the functions of a good life as outlined above appear consists mainly of the home itself and the tools, appliances and social organization controlled by household members. On average, Swedes spend about 65 percent of their time in their homes on week days, and about 75 percent on weekends [11]. People undertake daily efforts that all entail energy use to various degrees, and we hope to increase knowledge of this complex issue and develop a knowledge base from where we can start discussing how the need to conserve energy can be turned into something positively valued and worth striving for.

We regard the household as a social unit in which its members negotiate (in talk and in actions) their interest in indoor climate and energy-related issues and appliance use. Consequently, taking household members in the context of their household as the starting point will increase our knowledge of whether, how, and for whom energy is an issue in daily life. This approach yields information about the relationships and mutually dependent activities in common household projects. We assume that the complex inter-relational web produced when different activities in support of the same goal are performed by different household members will help us detect and understand both the factors underlying energy use and the potential to reduce it. We also investigate daily activity patterns at the aggregate level—the outcome of many households’ negotiations—to identify what activities that need much energy and thus might have significant conservation potential.

3. A Bottom-Up Approach to Energy Use and Everyday Life

Most research into energy use takes energy supply as its point of departure, and regarding energy as a scarce resource naturally leads to a focus on how to *increase* the energy supply

[4]. Since this has long been the case, industrial production, the transportation of people and goods, and public and private services are expected to need more energy as economies grow. The users' utilization of the energy supply has not been an issue of discussion. From a climate perspective, however, we must rethink the one-sided focus on supply [12]. We will therefore take a comprehensive view of energy use and energy efficiency in everyday life. Such an approach regards everyday life as a totality that brings meaning to people, a totality in which the aspects addressed above are interwoven. Since the research subjects regard their everyday life as a totality, we too must do so if we are to truly grasp peoples' energy use in daily life. By taking a socio-technical system approach to energy use in households, we can gain admittance to what the field of system studies often calls the "black box" of households [2], and analyze energy use and efficiency from the household members' perspective. We focus on the household member as an energy user and view her or him as an active subject in both the household and a broader system context. Housing sector companies and householders are local decision-makers determining the material frames for households' energy behavior in their dwellings—their "opportunity space[1]"—and their actions influence politicians, planners and companies in determining the institutional frameworks for action.

We use a time-geographic approach, which allows looking at everyday life as a totality, and weaves individuals together in terms of them performing activities that make them pursue household projects aimed at achieving household goals. From household members' time diaries [14-15], we can analyze and learn about when, where and what energy-related activities occur in a household context and by whom (and in what social context) they are

---

[1] Bo Lenntorp [13] defined the physical "space of possibilities" as the geographical area a person can reach, given a maximum speed for transportation, from a given location at time t1 when s/he has to be at the same or another location at time t2. This definition determines the space of possibilities without taking organizational and private restrictions into consideration, and we use of the term "opportunity space" to also include the latter aspects.

performed. Information is collected regarding who is involved in specific energy-use-related activities and routines that involve various constellations of household members [16-17].

The time-geographical approach underlines the importance of the material resources framing everyday life. Energy use is negotiated between the members of the households, and various material restrictions influence the outcome of the projects they undertake. Simon Guy and Elisabeth Shove [18] criticized the view that energy-saving actions are straightforward consequences of informed rational action on the part of individual decision-makers. Rather, they argue that it is necessary to understand the social structures and networks within which these decisions are made. Shove [19] also highlights the social and institutional contexts in which decisions concerning the acceptance of sustainable energy solutions are made. Following science, technology and society (STS) studies, Shove emphasizes that decisions concerning, for example, the implementation of energy efficiency measures and how we use energy are made in particular social contexts: "What qualifies as a reliable, cost effective, worthwhile energy saving measure in one socio-cultural domain might count for nothing in another" [19, p 1809]. In this way, an individual's energy use reflects the context (material and social, as well as in terms of activity patterns or routines) in which that person lives.

When applying this combination of theoretical perspectives, energy use is put into a material framework in time and space and regarded as embedded into social processes [cf. 20]. In this way, our understanding of energy use is built on knowledge about routines and institutions, and methods established in social contexts and in communication between household members and other actors. The time-geographical perspective also brings the meanings of time, place, and materiality into consideration. Nowadays, there is a claim that we need to "save" time, and this is problematized in time-geography by the concept of the context of everyday activity, as restricted by physical surroundings such as infrastructure, buildings, energy performance and appliances. There are exactly 24 hours per day and individual and energy use can help by speeding up processes while simultaneously reducing the need for humans to act when goals are fulfilled.

Since energy is embedded in most aspects of daily life, we will start from the household context of everyday life and the activities performed by householders to achieve their goals. How this is done varies from individual to individual, from household to household and from time to time, and our currently vague knowledge about the patterns generated by these activities is the main argument for choosing a bottom-up perspective. The climate change issue demands that we determine how welfare can be created and maintained without the energy misuse experienced today. In this article, we take the household as the contextual starting point for problematizing the basic functions to be discharged by household members performing their daily activity sequence, and how this relates to the need for energy.

4. Influence Energy Consumption – Information and feedback

The adoption of energy-efficient (and energy wasteful) technology is done on an everyday basis and is not often examined. Elisabeth Shove [21] emphasizes the importance of understanding consumption, technology and social change from the perspective of “invisible practices”. When it comes to energy systems consumers are often not interested in energy per se, but rather in the functions and conveniences that energy can provide. Energy is required for needs such as preserving and preparing food, supplying heat and light, and maintaining health and sanitation. How energy is produced and distributed is not relevant from this point of view; the important thing is fulfilling those needs. (However, it might be relevant for the environmentally engaged person who emphasizes environmentally friendly energy production) [22-23]. The overall goal must in the end be to introduce ecologically sustainable solutions and then meet the challenge of integrating these solutions in such a way that they provide and sustain what people consider to be normal services.

Earlier evaluations and follow ups of general information measures, through statistical analysis and surveys, shows that it has been hard to see what the result is of a single campaign and what measures that users should have taken anyway [24]. Estimation has however suggested that it would be possible to reduce energy consumption with up to 30 percent of current energy demand by using feed-back and/or tailored information [25-27]. In our case studies the householders also requested individually tailored, specific information related directly to their houses or living conditions. René Benders et al. [28] identified personalized information as information based on the specific characteristics of the household. Tailoring information takes personalized information a step further, since the householders receive reduction options that best suit the preferences of the households. Linda Steg [29] concluded that tailored information is more effective than general information in changing behavior. There are, however, a limited number of studies done on how to design tailored information to meet different households' needs. Steg suggested that it is possible to tailor information on energy saving options that are relevant for a particular household, or to address a person's economical or environmental concerns. Feedback is seen as a form of personalized information—such as a meter that provides detailed information on families' energy usage—to increase households' knowledge on how much energy they use in total or for different appliances [30].

It can however be hard for a householder to understand the connection between behavior and a figure showing the energy consumption. Through feedback a householder can be more directly and immediately aware of their energy consumption and of both the financial and environmental consequences of this use. A review of 38 studies of household energy use conducted over the last 25 years in Europe and the US showed that information feedback on rates of consumption can increase awareness and motivate decreased energy use [31]. At the same time, feedback signals connecting resources with for example its environmental impact is indirect and often difficult for a person to understand and react to [31-33].

There are different types of feedback that can be used. *Historic feedback* makes it possible for the households to compare their current consumption with their previous energy consumption. *Comparative feedback* is basically a way to relate a specific household's consumption to other households' consumption. *Breakdown feedback* is shows how electricity is used, subdivided by household appliance and other energy-demanding products [34]. Breakdown feedback could be useful where there a general lack of knowledge among consumers about what actually consumes energy in their homes [35]. In a Danish study the research design was based on the customer providing information themselves, which make it possible for the researchers to prepare breakdown feedback. The idea was that the household through an Internet based portal received a personal analysis of their electricity consumption. The internet site estimated the consumption of the household machinery.

As we will discuss below a similar idea is behind the use of VISUAL TimePAcTS/energy use where the provision of data come from the householder and where energy use is estimated by a model developed by Widén [36] is used. VISUAL-TimePAcTS/energy use in addition relates energy use to the householders uninterrupted activity sequence, hence giving the wider activity context of the energy use.

5. Activity Generated Patterns of Energy Use at Household and Aggregated Levels

In order to capture household electricity use as it is generated from the activities performed by householders, we have developed software called VISUAL-TimePAcTS/energy use[2], which tracks the relationship between activities and appliance use. Activity sequences are recorded in time diaries and a model for accounting electricity use is developed. Our approach builds on individuals' diaries as raw data, hence, we follow the activity sequence actually performed. Tanimoto et al [37-38] developed a method for generating inhabitants' behavioral schedules to predict energy consumption. They use a probabilistic tool to generate activity sequences ascribed to individuals, instead of taking their point of departure in raw data from time diaries. From the constructed activity sequences they produce load curves.

When developing our software and demonstrating how it works, we used a database consisting of 463 individuals' (in 179 households) time diaries from one week day and one weekend day per person.[3] This database was used as the empirical grounds for developing software that uses peoples' activities to account for electricity use by the appliances needed to perform the activities. There are two model schemes according to which electricity use is demanded from appliances used. One scheme demands electricity while the activity is performed (watching TV, ironing, etc.); the other demands activity for a limited time after the activity (the washing machine, dishwasher, etc.). The model schemes are is tested and validated in a small scale study by comparing the model result with measurements in the same households [39]. Here we will illustrate how activities identified in the diaries demand

[2] VISUAL-TimePAcTS: VISUAL= visualization, P=place, Ac= activity, T=technology, S=social companionship, and Time is, of course, time.

[3] The diaries were collected in a pilot study conducted by Statistics Sweden in 1996. The age span is from 10 to 97 years, and the study includes households of different sizes from different parts of Sweden. The empirical material is old and much has happened concerning electricity efficiency since then. However, we had to use the sole data set existing to test our model. It is not difficult to change the parameters for electricity demanded by various appliances.

electricity, as well as the resulting load curve, by looking at one household and all households in the database with adults aged 20 to 35 years with children living at home [19; 39-41].

VISUAL-TimePAcTS/energy use visualizes peoples' activities performed as a sequence in the course of the day, from midnight to the following midnight, just as they are written in the diary. That is why it is easy for people to recognize their days when talking about it [14], and why it is a good way to begin discussions on how changes can be made to a specific household's everyday activity patterns. The discussion then starts with what it is like today (the visualization of the diaries and the energy use generated from them) and from this point it is possible to judge whether or not it is possible to change the order of activities, who will perform the activities and if the activities are performed in an energy efficient way or not.

5.1. Activity Pattern and Electricity Use in a Household

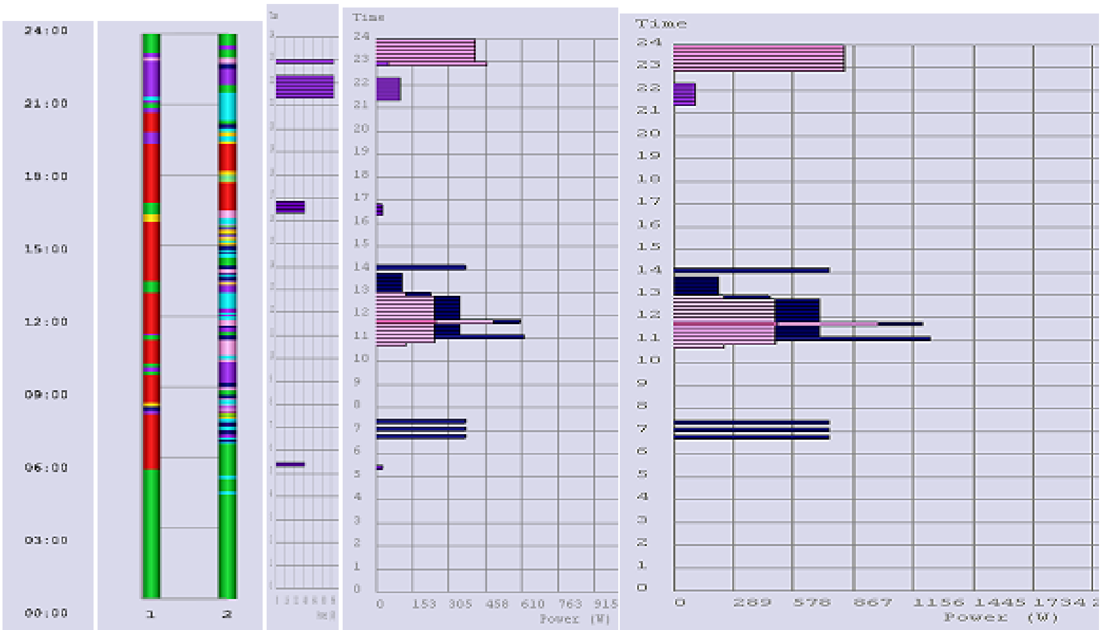
The example below is from a household with two adults and five children. Both the mother and father work outside the home, but the father also works while at home. The children are not in childcare so one adult must be available for the children throughout the day. Figure 1 presents the definition of main activities and the color legend used for the visualization of activities.

Figure 1. The main categories used when coding the diaries, and the color legend of the categories used in the software visualizations.

The colour legend of activities in the main categories used in VISUAL-TimePAcTS
Care for oneself
Care for others
Household care
Reflection/recreation
Movement/travel
Procure and prepare food
Employed work/School

Figure 2 shows the activity sequences of the two adults in the household. There is a big difference between the man and the woman in the time allotted for work. Another difference is that the woman's day is much more scattered, since there are more activities.

Figure 2. (a) Time of day. The day should be read from the bottom upwards, starting with sleeping after midnight for both adults. (b) Activity sequences performed during the same week day of the man (left, 1) and woman (right, 2) in a household with 5 children. The activity sequences are visualized at the main category level. (c) Electricity use generated by the man's activities, only the appliances related to primary use in the reflection/recreation activity sphere appear (max 100W). (d) Electricity use generated from the woman's activities (max about 620 W). (e) the total energy use in the household as generated from the activities of the adults (max about 1200W). Observe that the scale for the man is not the same as for the women in the d) part of the figure.



a b c d e

In this household the activities performed by the woman generate the most electricity use. She is at home most of the day, while the man is at his workplace (the red parts of his sequence after the first and before the yellow parts (transportation) in his sequence. The woman uses a lot of electricity for household care purposes (bright lilac) and also for cooking (blue).

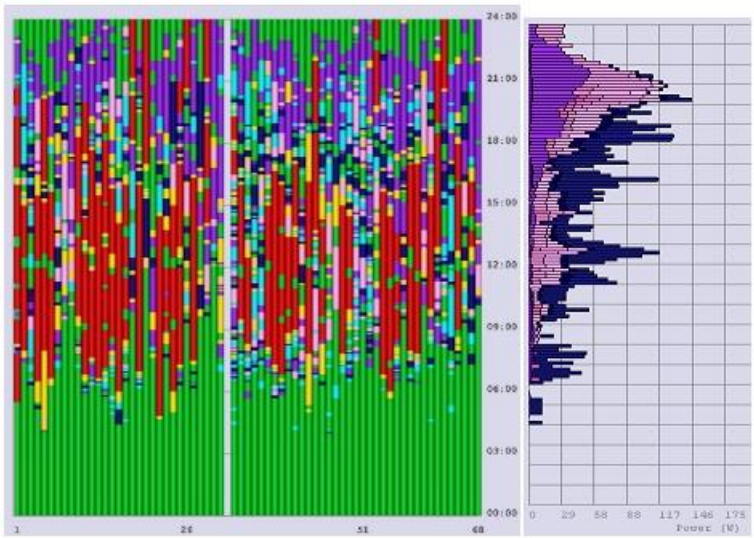
Of course, when people are at home, they use more electricity for home-based activities than when they are away from home. While it is normal in Sweden that the man of the household is the individual registered with the energy company, information sent to households where the man is not the one who performs most of the home-based activities requiring electricity will not reach the person in charge of those activities. This piece of knowledge is important to the energy companies if they want to influence the use of electricity in housesholds.

The activity pattern for all households with two adults and children in our database is shown in Figure 3. There are 68 diaries from week days, and more women than men in the households wrote diaries (28 men and 40 women). It is obvious that the women in general have more scattered activity sequences than the men, and that men work more than women. This aligns with other statistics [42-43]. In early mornings, women perform care for others' activities (i.e., taking care of children).

In the illustration of the single household in Figure 2, the woman used much more electricity than the man, and this difference readily came to the fore. Since this might be a special case for this household, we compared energy use for men and women between the ages of 20 and 35 with children. The result, presented in Figure 4, shows the load curves on week days for men and women, respectively.

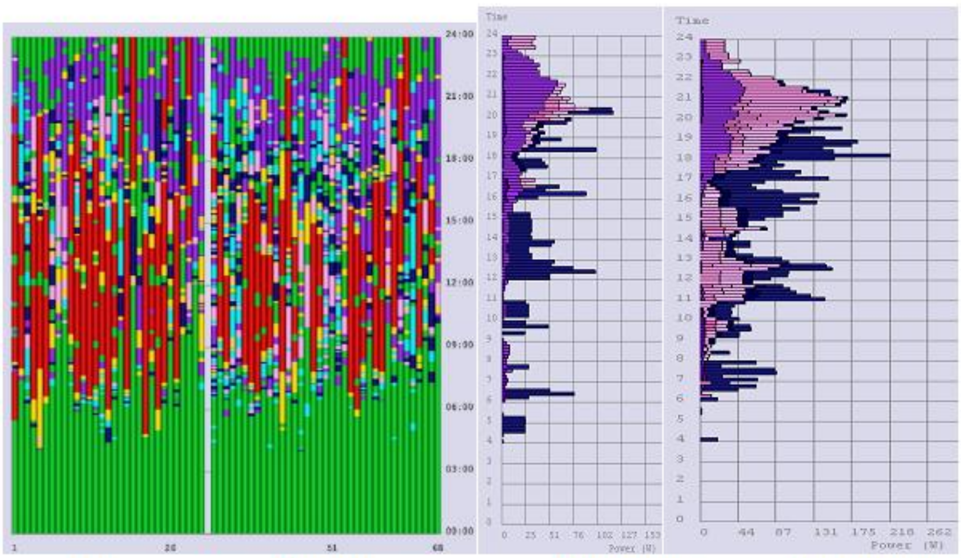
The pattern that men between the ages of 20 and 35 with children use less electricity than women in the same group do for home-based activities on week days is clear. There is not only a difference in the amount of energy used, it is also obvious that household care (light lilac) activity-generated electricity use mainly emanates from women's activities. While men participate in preparing food (dark blue), women seem to bear the main responsibility for this activity. When it comes to electricity used for reflection/recreation purposes, the differences between men and women is not very large.

Figure 3. Activity pattern on week days among men and women aged 20 to 35 living in households with children (N=68). In the left part of the figure, the activity sequence of each individual man (n=31) and woman (n=37) in the group are placed beside each other (men in the left part of this partition of the figure and women to the right). The right part of the figure shows electricity use (10-minute intervals) per individual in families with children (N=68).



Men **Women** **W/individual**

Figure 4. (a) Activity patterns among men and women in households with two adults between the ages of 20 and 35 and children (= Figure 3). (b) Activity-generated load curves for electricity among men in the group, and c) among women in the group.



Men **Women** **W/ind. man** **W/ind. woman**

a b c

The examples of activity-generated electricity use provided here at the household and group level show that different kinds of information should probably be developed, and that it should be tailored differently to men and women in the same age group—at least if they live with children in the household.

6. Feedback and Visualization

One way to tailor and personalize information is to have households write time diaries and utilize the VISUAL-TimePAcTS/energy use software to show when activities that consume energy are performed in the context of their own daily lives. This will provide direct feedback to the diarists, since the visualization is based on their own information. When discussing the energy outcome, it is evident what activities can be changed and which ones cannot be changed, since they are part of an activity sequence that cannot be changed without losing value to the householders' goal of maintaining a good life. Dr. Kristina Karlsson of Linköping University is currently implementing this kind of approach in one of her research projects. The energy use calculations of VISUAL-TimePAcTS/energy use are until now based on appliances used in the home.[4] Even though it is possible to include also energy for transportations and for heating, lighting and hot water we have not yet included it in the model.

In our case studies, we have also seen that the energy use was successfully reduced only when specific information was combined with concrete measurement techniques and experimentation. Although awareness of energy and environmental issues can be high, it is sometimes difficult to understand the implications of this awareness in practice, and several of our householders were shocked when they saw how much energy their activities consumed

[4] VISUAL-TimePAcTS/energy use will be available on the web during 2010.

[2]. Keeping energy consumption statistics over a longer period of time also contributes to energy reduction at home. We have also evaluated the method in a case study. We then let households keep time-diaries and we followed up with interviews. During these interviews, graphs emanated from the actual time-diaries of the person being interviewed, are shown and discussed with the interviewee. The model was able to visualize behavioural patterns in the household and facilitates the interpretation of movements and activities in time and space. A better and clearer view of the everyday life of the informant has been obtained [44]. By combining time-diaries with interviews it is possible to obtain information on in which context different decisions are being made, and also an insight to possibilities and restrictions concerning the abilities to change energy-related behaviour that are present in the household.

Using tailored information in combination with feedback is a way of focusing and promoting energy efficient behavior while accepting and supporting individual activity patterns and peoples' wish to shape their own everyday lives.

7. Conclusions

Our starting point has been energy use and potential energy conservation in the housing sector from a household-level perspective. The need to analyze and understand energy consumption in relation to households' activity patterns is vital for developing policy means that can contribute to both energy efficiency and what people deem as a good everyday life. Deepened knowledge is needed about how energy use contributes to everyday life today.

Often energy efficiency advice is so general that households have difficulties relating to it. They cannot grasp what it would actually mean for their own energy consumption if they implemented this kind of advice. Therefore it is very important to relate information to the households' own activity patterns and their rhythms of everyday life. In this context time-diaries and VISUAL TimePAcTS/energy use contributes with clear, simple diagrams where peoples' activity patterns are combined with a curve on how much energy that was needed for various daily activities (breakdown load curves).

By utilizing many time diaries from a population we can also discover differences in activity patterns for example between men and women, single households and families, adults and children. We can also visualize activity patterns in a household during a period and, through that, discuss and problematize consequences for energy consumption. We have discussed the fact that women's activities are more scattered throughout the day, and that they actually use more electricity at home than men do. The individual woman in our example was at home more than the man, so when giving feedback to this household and tailoring energy consumption information, it is more important to relate to the woman's activity patterns. In general, women used more electricity for activities related to cooking and household care than men did, which makes them the most relevant target group when it comes to give feedback on how much electricity an appliance use or alternative ways of doing certain activities. The whole household, however, should always be included in discussions on how their activity patterns relate to each other, and how they, as a family, could contribute to more energy efficient activity patterns.

Energy consumption related to reflection/recreation activities was more similar among the individuals of the population and differences in relation to activity patterns were seen in relation to whether the households contained children or not. When discussing energy consumption in relation to recreation, the focus should be on the households' combined activity patterns and the opportunities for finding, for example, coordination gains.

In this way, time diaries and the VISUAL-TimePAcTS/energy use software are useful for learning more about everyday activities that need energy, or for policy-makers and others that want to reach out to householders with tailored information about energy efficiency. But this method is just as useful for the households as a reflective tool when discussing families' daily lives in relation to energy consumption. The method provides direct feedback to households and the information is valid since it emanates from their own reported activities. It is then possible to begin discussions on how activities can be changed and energy consumed without losing values and routines that the households believe contribute to maintaining their good life.

Acknowledgements

The research for this paper forms part of the research program Energy Choices in Households: A Platform for Change. This research is funded by the Swedish Energy Agency.

References and Notes

[1] COM/2008/0030 final/, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions—20/20/20 by 2020—Europe's climate change opportunity.

[2] Palm, J, The public-private divide in household behavior: How far into the home can energy guidance reach? Energy Policy 38 (2010) 2858-2864.

[3] Carlsson-Kanyama, A. Lindén, A.L. Hushållens Energianvändning: Värderingar, Beteenden, Livsstilar och Teknik. En litteraturöversikt. Fms-report 2002:176. Stockholm University, Stockholm, Sweden, 2002.

[4] Gyberg, P. Palm, J. Influencing households' energy behavior: How is this done and on what premises? Energy Policy 37 (2009) 2807–2813.

[5] Ek, K. Söderholm, P. The devil is in the details: Household electricity saving behavior and the role of information. Energy Policy 38 (2010) 1578–1587.

[6] Karlsson, K. Widén, J. Hushållens Elanvändningsmönster Identifierade i Vardagens Aktiviteter. Tema T Working Paper 330; Linköping University, Linköping, Sweden, 2008.

[7] Widén, J. Wäckelgård, E. A high-resolution stochastic model of domestic activity patterns and electricity demand. Applied Energy 87 (2010) 1880–1892

[8] Lindén, A.L. Miljömedvetna Medborgare och Grön Politik. Formas, Stockholm, Sweden, 2004.

[9] Holmberg, J. Nässén, J. Energy efficiency: A forgotten goal in the Swedish building sector? Energy Policy 33 (2005) 1037–1051.

[10] Swedish Energy Agency. *Energy in Sweden. Facts and Figures*; ET 2009:29, Swedish Energy Agency, Eskilstuna, Sweden, 2009.

[11] Ellegård, K. Lockropen ljuder: Kom.hem, in: Amnå, E.Ilshammar, L (Eds), Den gränslösa medborgaren – en antologi om en möjlig dialog, Agora, Stockholm, Sweden, 2003; pp. 119–148.

[12] IPCC. Summary for policymakers. Retrieved 9 June 2007 from http://www.ipcc-wg2.org/index.html, 2007.

[13] Lenntorp, B. Paths in space-time environments. A time-geographic study of movement possibilities of individuals. Meddelanden från Lunds universitets geografiska institution nr 77, Lund, Sweden, 1976.

[14] Ellegård, K. Nordell, K. Att byta vanmakt mot egenmakt. Självreflektion och förändringsarbete i rehabiliteringsprocesser Metodbok, Johansson & Skyttmo, Stockholm, Sweden, 1997.

[15] Ellegård, K. A time-geographic approach to the study of everyday life of individuals—a challenge of complexity. GeoJournal 48 (1999) 167–175.

[16] Ellegård, K. Hushåll, energi och vardagliga aktiviteter—ett perspektiv på effektivisering av energianvändning från hushållsnivå, in Palm, J. Ellegård, K. (Eds.), Vardagsteknik: energi och IT. Forskning om hållbar användning av samhällets IT- och energisystem, Carlssons, Stockholm, Sweden, pp. 144–171, 2008.

[17] Widén, J. Lundh, M. Vassileva, I. Dahlquist, E. Ellegård, K. Wäckelgård, E. Constructing load profiles for household electricity and hot water from time-use data: Modelling approach and validation. Energy and Buildings 41 (2009) 753–768.

[18] Guy, S. Shove, E. A sociology of energy, buildings and the environment. Routledge, London, UK, 2000.

[19] Shove, E. Gaps, barriers and conceptual chasms: theories of technology transfer and energy in buildings. Energy Policy 26 (1999) 1105–1112.

[20] Palm, J. Thollander, P. An interdisciplinary perspective on industrial energy efficiency. Applied Energy, 87 (2010) 3255-3261.

[21] Shove, E. Comfort, Cleanliness and Convenience. Berg: Oxford, UK, 2003.

[22] Löfström, E. Palm, J. Visualizing household energy use in the interest of developing sustainable energy systems. Housing Studies 23 (2008) 935–940.

[23] Palm, J. Tengvard, M. Motives for and barriers to household adoption of small-scale production of electricity: examples from Sweden. Sustainability: Science, Practice, & Policy (in press).

[24] Bemelmans-Videc, M.-L. Rist, R. Vedung, E. (Eds.). Carrots, Sticks, and Sermons: Policy Instruments and Their Evaluation. Transaction Publishers, New Brunswick, N.J, 1998.

[25] Ehrhardt-Martinez, K. Laitner, J. A. McKinney, V. The Behavioral Continuum: The Nation's Behavior-Based Energy Savings Potential. ACEEE, Washington, DC, 2008.

[26] Gardner, G. Stern, P. The short List: The Most Effective Actions U.S. Households can take to Curb Climate Change. Environment 50 (2008) 12-24.

[27] Laitner, J. Ehrhardt-Martinez, K. McKinney, V. Examining the scale of the Behaviour Energy Efficiency Continuum. In Proceeding of the ECEEE summer study Act! Innovate! Deliver!Reducing energy demand sustainably, June 1-6 2009, La Colle sur Loup, Côte d'Azur, France, pp 217-223.

[28] Benders, R. Kok, R. Moll, H. Wiersma, G. Noorman, K. New approaches for household energy conservation: In search of personal household energy budgets and energy reduction options. Energy Policy 34 (2006) 3612–3622.

[29] Steg, L. Promoting households energy conservation. Energy Policy 22 (2008) 145–155.

[30] Darby, S. Why, what, when, how, where and who? Developing UK policy on metering, billing and energy display devices. In Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings, August 18-22 2008, Pacific Grove, California, pp. 70–81.

[31] Darby, S. Making it obvious: designing feedback into energy consumption. In Proceedings of the 2nd International Conference on Energy Efficiency in Household Appliances and Lighting, Italian Association of Energy Economists/ EC-SAVE Programme, 27-29 September 2000, Naple, Italy.

[32] Roberts, S. Baker, W. Towards effective energy information: improving consumer feedback on energy consumption. Report, Centre for Sustainable Energy, Bristol, UK 2003.

[33] Petersen, J. Shunturov, V. Janda K. Platt, G- and Weinberger, K, Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. International Journal of Sustainability in Higher Education, 8 (2007) 16-33.

[34] Hallin, T.; Lindstedt, I. Svensson, T. Presenting consumption graphically – the complete story. Elforsk report 07:44, Stockholm, Sweden 2007.

[35] Brange, B. Fjordbak Larsen, T. Wilke, G. Campaign effects and self-analysis Internet tool. In Procceding of the ECEEE summer study Act! Innovate! Deliver!Reducing energy demand sustainably, June 1-6 2009, La Colle sur Loup, Côte d'Azur, France.

[36] Widén, J. Distributed Photovoltaics in the Swedish Energy System - Model Development and Simulations. Licentiate Thesis, Department of Engineering Sciences, Uppsala University, 2009.

[37] Tanimoto, J; Hagishima, A; Sagara, H. Validation of probabilitsic methodology for generating actual inhabitants' behavior schedules for accurate prediction of maximum energy requirements. Energy and Buildings 40 (2008), 316-322.

[38] Tanimoto. J; Hagishima, A; Sagara, H. A methodology for peak energy requirements considering actual variation of occupants' behavior schedules. Building and environment 43 (2008) 610-619.

[39] Widén, J. Modellering av lastkurvor för hushållsel utifrån tidsanvändningsdata. Elforsk Report 08:54. Elforsk: Stockholm, Sweden, 2008.

[40] Ellegård, K. Cooper, M. Complexity in daily life: A 3D visualisation showing activity patterns in their contexts. *eIJTOUR*,37 (2004) 37–59.

[41] Vrotsou, K. Ellegård, K. Cooper, M. Exploring Time Diaries Using Semi-Automated Activity Pattern Extraction. *eIJTUR* 6 (2009) 1–25.

[42] Eurostat 2004. How Europeans spend their time. Everyday life of women and men. Data 1998-2002. Pocketbooks. European Commission, 2004.

[43] Statistics Sweden. Tid för vardagsliv. Kvinnors och mäns tidsanvändning 1990/91 och 2000/01. Levnadsförhållanden, Report 99, 2003.

[44] Löfström, E. Visualizing Energy in Households: the De-domestication of Socio-Technical Systems and Individual- as well as Artefact-bound Energy Use. Thesis, Dept. of Thematic Studies - Technology and Social Change, Linköping University, 2008.