Different Everyday Lives: Different Patterns of Electricity Use[1]

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ABSTRACT

The combination of two different sets of data comprised the background for a very detailed analysis of the patterns of domestic electricity use. The first data set included over 50,000 households coupling individual electricity use with socio-economic data on household members, building size and type etc. The second data set comprised 100 households with electricity consumption for every 10 minutes during one month for each appliance and for most lamps. The detailed analysis of the use of appliances was coupled with socio-economic and building data from a questionnaire and with qualitative interviews on everyday life and electricity use in 10 households. We find that background variables such as income and age do explain some differences both of total electricity use and in the distribution on different types of end-uses. Background variables however only explain some of the variations. From the qualitative interviews we learned that the question of being a "saver" or a "spender" seemed to give some further explanation of variations, even though we found a limited correlation between the end-uses the families were most aware of from a saving perspective and the most electricity consuming appliances in the household.

Introduction

The fact that different types of families use varying amounts of energy has been a theme in energy studies at least since the 1980s (Lutzenhiser 1993). Different studies have used different approaches to study these variations of energy use and the term lifestyle is used different. Some have seen lifestyle as simply being patterns of activities (Schipper et al. 1989), whereas others have defined it as "sets of values, behaviors, practices and possessions that are characteristic of a family" (Gladhart, Morrison and Zuiches 1986, p 17). A Danish energy study (Kuehn 1998) uses Bourdieu's concept of lifestyle that defines lifestyle by the notion of habitus which is a practical sense, an acquired system of preferences of how the world should be perceived and divided. Bourdieu's concept of habitus includes how humans take in the structures of the social world during childhood, and therefor the constitution of habitus is closely related to the cultural and economic capital of one's parents (Bourdieu 1998). The understanding of consumption in this perspective focuses on how higher social classes distinguish themselves from the lower classes by the things they posses, and in general how consumption is a way of establishing and communicating identity.

These three definitions of lifestyle could be seen as gradually expanding from covering only the pattern of activities, to including possessions and values to finally to incorporating explanations of where the values and activities originate and how they correlate to the possessions. However, no matter which of these concepts of lifestyle is used, all three studies

conclude that lifestyle and energy use do correlate. But a recent study shows that if we compare similar households according to all relevant background variables, we still find considerable differences in energy use (Gram-Hanssen 2002). This study thus implies that the concepts of lifestyle only partly describe the patterns of activities that are relevant for understanding energy use. This could be explained by the fact that energy is used for purposes that in a social sense are very different from each other. Tumble dryers and computers both use electricity though the social explanations for using them, and thus their correlation with background variables, may be very different. Furthermore other recent studies also question the strong focus on distinction and communication in the understanding of energy use and point toward further study of the understanding of routines (Shove 2003).

Taken together these studies imply that further research is needed on the specific daily practice that generates energy use. This research should focus on how daily practices actually vary between families and how they correlate with different background variables or with other more qualitative aspects of the families' everyday life. Furthermore it is relevant to state exactly to what degree the different socio-economic background variables correlate with household energy use and to what extent households, which are similar according to these variables, still use energy differently.

In this project we took advantage of two different sets of data already existing, which made it possible to investigate questions of daily practices as well as questions of how background variables correlate to electricity use. The next section, 'Methods', gives more details on the two sets of data and the content of our analysis.

Methods

A previous research project intended to draw maps of resource consumption, architecture and lifestyle in a whole city (Beck-Danielsen et al. 2004). For this purpose a GIS database was established with all available register data from the year 2000 coupled to each household in the city of Aarhus, the second largest city in Denmark. Using this database we have access to data from over 50,000 households including electricity consumption, socio-economic and demographic data, and data on the buildings. Extensive registration of both people and buildings in Denmark made it possible to establish this database. As researchers we are allowed to combine the Danish personal data net (the Danish CPR register containing information on income, education, age, nationality etc. on every person living in Denmark), and the national building data net (the Danish BBR register containing information on the year the building was constructed, size and type etc. of all buildings in Denmark) with meter readings in this case provided by the utility of Aarhus now called NRGi. Using ordinary least squares regression, electricity use was explained by socio-economic and housing data.

The other data set is established as part of the EU EURECO project including end-use recording in four European countries: Denmark, Italy, Portugal and Greece (Sidler, Lebot and Pagliano 2002). The purpose of the EURECO project was to assess potential savings for each appliance by comparing recorded consumption with simulated consumption by use of the most energy-efficient model of comparable size and type of appliance. The EURECO project included end-use recording in 100 Danish households (85 detached houses and 15 apartments) during one month in 1999 or 2000. The recording was performed with the DIACE system (Individual and Automatic Diagnostics for Electricity Consumption) where a discrete meter is plugged in series with each appliance and where data are automatically transmitted every 10 minutes.

Furthermore, a specially developed Lamp-meter kept track of lighting use every 10 minutes (Sidler, Lebot and Pagliano 2002).

In our project we have supplemented the EURECO data with a questionnaire on socio-economic background variables, values and practices. Even though the questionnaire survey was carried out more than 2 years after the recording, 71 of the 85 families living in detached houses answered the questionnaire. In the apartments many families had moved resulting in a response from only 3 of the 15 households. For that reason this part of the analysis only includes detached houses. Furthermore we selected 10 households for qualitative interviewing on everyday life, routines and attitudes in relation to electricity use. Interviews were structured with open-ended questions allowing the respondents to elaborate on their own understanding of the questions. Interviews were taped and afterwards thematically reported and partly transcribed. The selection of households for interviewing was based on two variables in the questionnaire giving best correlation with total electricity consumption: High/low incomes and Interested/not-interested in energy savings.

Analysis on Background Variables

The Aarhus database contained data on the electricity consumption of 67,000 households coupled with socio-economic and building data. From these data we have removed housing with business activities, weekend cottages, electricity-heated houses and households with extreme electricity use (defined as less that 500 kWh or more than 16,000 kWh). This leaves us with 53,804 households distributed on different types of housing as shown in Table 1.

Table 1. Household Electricity Use (Excluding Electric Heating) by Housing Type

Type of Housing	Number of Households	Average Elect. Use (kWh/year)	Standard Deviation	Danish Average Elect. Use (kWh/year)[2]
Detached houses	8573	4189	2062	
Semi-detached houses	4950	3114	1523	4042
Apartments	40,281	1720	865	1934

Presentation of households in the Århus database

As shown in Table 1, average electricity use is quite different for the three types of housing, which is the reason why we have chosen to analyze each type of housing separately. Table 1 also shows huge standard deviations telling us that there are big variations in electricity use within each type of housing. Table 1 furthermore shows that the average electricity use in our sample is quite comparable with national average numbers, though in apartments the lower level in our sample can be explained by a huge number of small apartments in Aarhus compared with the national average. Results from analyses of the three different types of housing are summarized in Tables 2, 3 and 4. In all tables each new line in the table represents an additional explanation where the effect of the above variables is accounted for. This means, for example, that the tables show the effect of a larger floor area when the effects from the number of persons and the income of the household are taken into account.

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[2]The Danish average electricity consumption is calculated on the basis of (Dansk Energi 2003)

Table 2. Detached Houses: Background Variables Effect on Electricity Use

Background Variables	Effect on Electricity Use	Explanatory Power
	kWh/year	Change in R^2 (%)
Per person in the household	541	27.6
Per 100,000 DKK in gross income	90	5.8
Per 10 sq. meter floor area	95	2.5
Per age square[3] of oldest person	-0.35	1.3
Per 0-6 years old children	-158	
Per 13-19 years old children	179	0.5
Long education compared with only primary school	-278	0.02

Based on analysis of the Aarhus database, n=8573

Table 3. Semi-Detached Houses: Background Variables Effect on Electricity Use

Background Variables	Effect on Electricity Use	Explanatory Power
	kWh/year	Change in R^2 (%)
Per person in the household	556	34.8
Per 10,000 DKK in gross income	100	4.1
Per 10 sq. meter floor area	99	2.1
Per age square of oldest person	-0.3	0.6
Per. 0-6 years old children	-211	
Per 13-19 years old children	159	1.0
Long education compared with only primary school	-247	0.3
Neither Danish nor Western citizenship	-797	0.3

Based on analysis of the Aarhus database, n=4950

Table 4. Apartments: Background Variables Effect on Electricity Use

| Background Variable	Effect on Electricity Use	Explanatory Power
	kWh/year	Change in R^2 (%)
Per person in the household	291	21.9
Per 100,000 DKK in gross income	20	1.3
Per 10 sq. meter floor area	119	7.2
Per age square of oldest person	-0.1	1.3
Per. 0-6 years old children	-76	
Per 13-19 years old children	117	0.3
Long education compared with only primary school	-63	0.1

Based on analysis of the Aarhus database, n=40,281

Simple regression analysis was first made to determine the order of importance for each background variable. This order is then used in the multiple regression analysis. For each type of housing we find that the number of persons living in the household is absolutely the single most significant explanation for electricity consumption. The more people living in the household, the more electricity is used. However Figure 1 shows that it is more energy efficient to have more people in a household as the electricity use per person decreases with the number of people living in a household. The background variable with the second and third largest explanatory power is the income of the family and the floor area of the dwelling. Other analysis (not shown) shows that these two variables are strongly interrelated, especially for detached and semi-detached houses. Together the number of persons, floor area and income level explain between

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[3]In the multiple regression analysis the actual age, and not only the age square is used, in order to follow "the hierarchical principle", the actual age however has no explanatory power.

30% and 40% of the total variation in electricity use in the three different types of housing, which also means that 60%-70% of the variation in electricity is not explained by these variables.

Figure 1. Average Electricity Consumption per Household and per Person Compared with the Number of Persons Living in the Household

Number of inhabitants
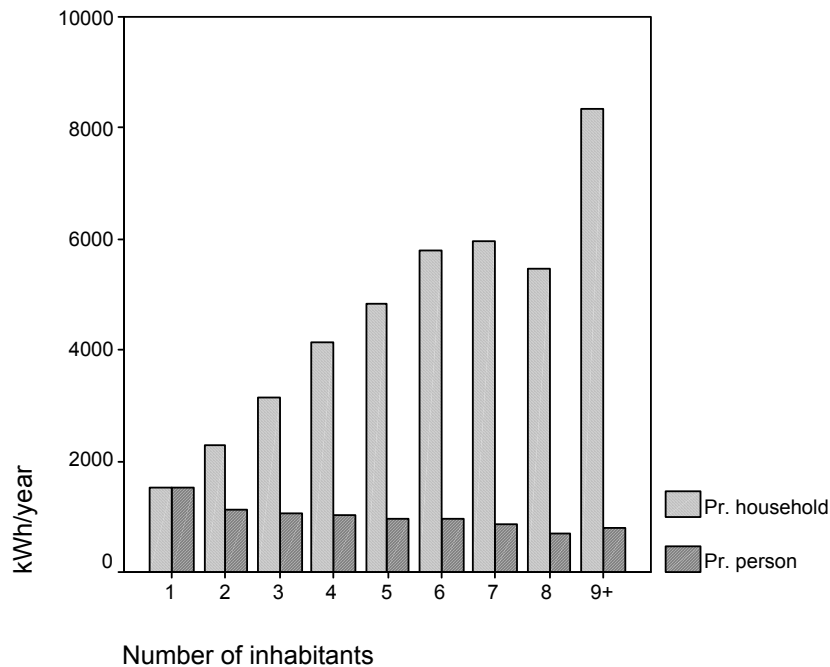
Source: Aarhus database. Note: 9+ refers to 9 or more inhabitants, n=53,804

If we look at age, education and ethnicity, we find that their explanation of the overall variation in electricity use is very small (totaling less than 2%) if we have already taken into account the effect of number of persons, floor area and income. However as Tables 2, 3 and 4 also show, there is actually a significant correlation between each of these background variables and electricity use. But they explain little of the total variation as each variable is only relevant in a minor part of the households.

We have looked at age in two different ways. On one hand, as an indicator of the age or stage in lifecycles of the whole family, we have used the age of the oldest person in the household and have compared this to the use of electricity (Figure 2). In this figure only age (of the oldest) and number of persons (as electricity use is divided with number of persons in the household) are considered. What we see here is a tendency that electricity use is higher during the stages of life when children have moved from home (55 years and over) than in the stages when children live at home. This could be explained by cycles where people gradually equip their homes with more and more appliances as the children grow up and household income increases. However when children leave home, most of the appliances stay, only now there are fewer persons to share the electricity use.

The other way we have dealt with age is to look at the effect children have at different ages. The question is whether there is any effect on electricity use if one or more of the persons living in the household is 0-6 years, 6-12 years or 13-19 years old. As concluded in Tables 2, 3 and 4, the general result here is that small children (0-6 years) use less energy than average (75 - 210 kWh per year) whereas teenagers (13-19) use more electricity than average (117-179 kWh
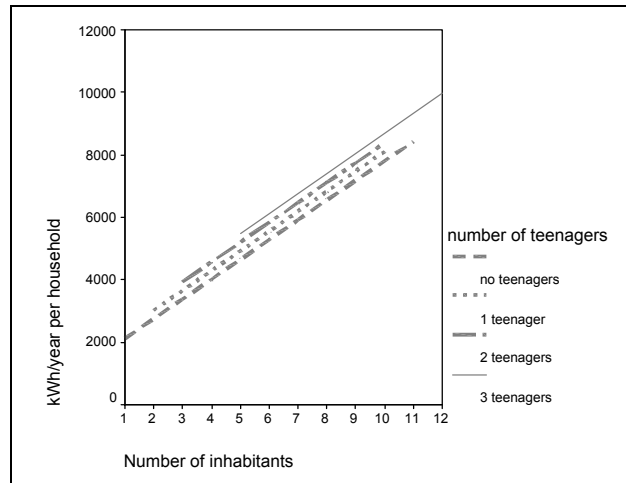
per year). An example of this is shown in Figure 3, namely the effect of 1-3 teenagers in semi-detached houses.

Figure 2. Average Electricity Use per Person in Relation to Age of the Oldest Person in Households in Detached Houses
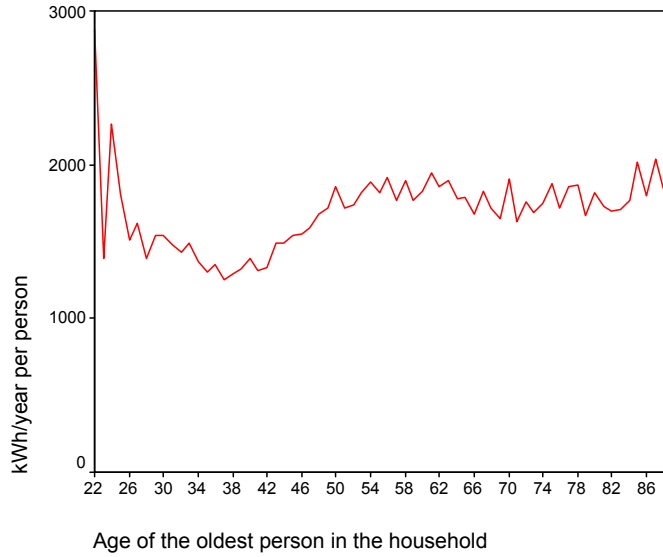
Source: Aarhus database, n=8573

Figure 3. The Effect on Electricity Use of Teenagers in Semi-Detached Houses


Source: Aarhus database, n=53,804

The last background variables, which should be mentioned, are education, ethnicity and gender. The explanatory power of all three on the total variation is less than one percent, but even so there might be interesting aspects of these variables. In general we find that the longer the education, the higher the electricity use. This however relates to the correspondingly growing income. If income is taken into account, long education compared with no education actually has a positive influence on electricity saving. We find that households with no further education than

primary school on average use over 200 kWh per year more than households with high education in detached and semi-detached housing. Our indicator of ethnicity is citizenship divided into Danish, other Western and "the rest", with any combinations in the household of these three types. If all other variables are taken into account, we find that households with non-western citizenship on average use 800 kWh per year less than Danish or Western citizens but only in semi-detached housing.

End-Use Analysis Comprising 100 Households

The analysis described above focused on the total electricity consumption for a household. However, the end-use of electricity serves purposes that have a very different practical and social meaning. Analysis of extensive metering of 100 households enables a closer look at the different appliances using electricity. The average of the total electricity consumption per household on detached houses was 3764 kWh and on flats was 2039 kWh, which is in line with the national figures shown in Table 1. Furthermore, comparing electricity use to the number of persons in the household plus size and type of home gives a correlation quite similar to what was found for the Århus-database. This indicates that the 100 households - according to their electricity consumption levels - seem to be representative on a national Danish level. Figure 4 shows the average electricity consumption divided on eight major end-use applications[4].

Figure 4. Electricity Consumption Distributed on Eight End-Uses on Average for 100 Households
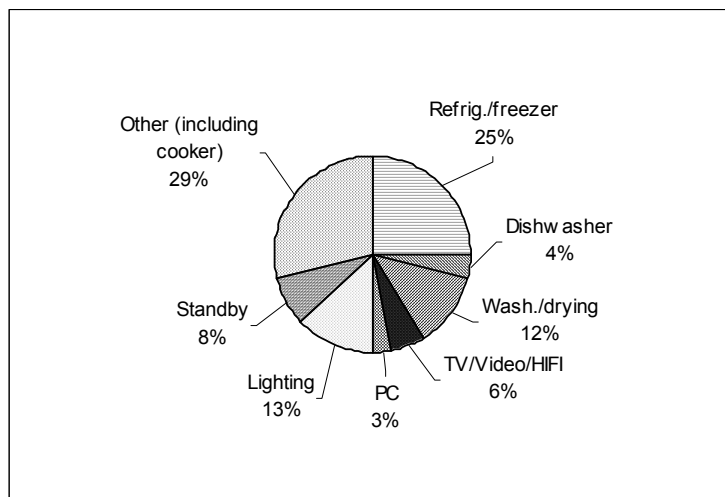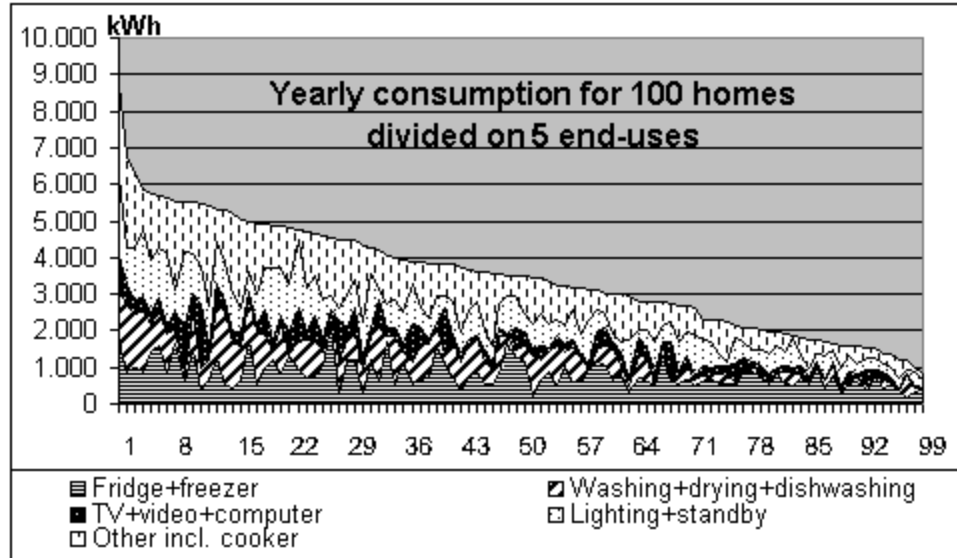

Source: Odense data, n=100

Figure 5 shows huge variations in the end-uses for the 100 households. The 100 households are shown on the x-axes with number 1 having the highest total consumption falling to the household with the lowest total consumption. Electricity used for refrigerators and freezers varies with several hundred percent from one household to another independently of the total electricity consumption and it is a relatively high consumer of electricity for all 100 households.

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[4]The category "Other" contains cooking along with assorted small appliances. The category "Standby" includes electricity consumption when not in use from TV/Video/HIFI (63%), from PC's including equipment (24%) and from microwave ovens, chargers for mobile phones etc (12%).

On the other hand, the electricity consumption for other (including cooker), washing+drying+dishwashing and for lighting+standby correlates more closely with the total consumption.

Figure 5. Variation in End-Use Consumption for 100 Households

Source: Odense data, n=100

Can these differences in end-use consumption be explained by background variables? Table 5 shows the percentage distribution on end-uses related to the age of the oldest person in the household (taken as an indicator of the whole family's place in the lifecycle). The total consumption depends on the family's stage in the lifecycle, with the most electricity consumed between 30 and 50 years of age. The actual amount of kilowatt-hours (not shown, can be calculated from the figures in Table 5) used by refrigerators and freezers does not depend on age. Dishwashing and washing/drying make up a smaller percentage of the total electricity use among older people compared with younger people, whereas older people use a larger share of their electricity on lighting compared with younger people. Older people use as much electricity for computers, television/radio as younger people, but it seems as if older people are more likely to turn off the standby consumption.

Table 6 shows the actual distribution of electricity on end-uses in relation to the income of the household. The consumption on refrigerators/freezers and television/radios does not seem to depend on the household income. Growing consumption with growing income is mainly due to the end-uses: computer equipment, standby and other (including cooker) and partly to dishwashing, washing/drying and lighting. Figure 7 shows end-use consumption related to the interest in saving energy. The consumption for refrigerators and freezers seems independent of income and age as well as interest in saving energy, whereas consumption on washing/drying, TV/radio, lighting and standby are dependent on the attitude to energy saving. More analysis shows a tendency that older people care more about saving energy (not shown here).

Table 5. Distribution in Percentage of End-Use of Electricity in Detached Houses in Relation to Age

Oldest persons' age	Average electricity use	Number of households	Refrigerator/freezers	Dishwasher	Washer /dryer	TV / radio	Computers etc.	Lighting	Standby	Other (inc. Cooker)
Years	*kWh*		%	%	%	%	%	%	%	%
20-29	2950	2	29	0	18	11	2	10	10	22
30-39	4154	17	19	7	14	5	3	12	10	30
40-49	4070	25	22	4	12	6	4	13	11	29
50-59	3911	17	28	3	10	6	4	13	11	25
60-69	3063	5	38	3	7	3	3	14	7	26
70-79	3018	5	30	2	7	6	4	15	12	24

Source: Odense data, n=71

Table 6. Distribution of Actual End-Use of Electricity in Detached Houses in Relation to Household Income

Household income	Average electricity use	Number of households	Refrigerator/ freezers	Dishwasher	Washer /dryer	TV / radio	Computers etc.	Lighting	Standby	Other (inc. Cooker)
DKK	kWh		kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh
1-200,000	2752	5	713	115	332	215	49	328	269	732
2-300,000	3133	11	911	66	245	196	105	528	273	809
3-400,000	3081	8	685	85	392	188	128	312	420	871
4-500,000	4475	19	1095	205	557	273	156	553	448	1188
5-600,000	4084	14	714	251	476	194	122	552	368	1406
6-700,000	3774	5	829	145	416	207	274	517	601	782
> 700,000	4997	6	748	304	898	188	221	710	517	1413

Source: Odense data, n=68

Table 7. Distribution of Actual End-Use of Electricity in Detached Houses, in Relation to the Households Own View of Their Carefulness in Saving Energy

Careful about saving energy	Average electricity use	Number of households	Refrigerator/ freezers	Dishwasher	Washer /dryer	TV / radio	Computers etc.	Light	Standby	Other (inc. Cooker)
	kWh		kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh
Yes, very	3515	28	870	181	391	193	113	433	354	980
Yes, some	3802	31	848	140	432	219	169	480	390	1126
Normally not	4906	12	892	264	739	259	144	796	559	1256

Source: Odense data, n=71

Qualitative Interviews

To go further into the understanding of why some families are more interested in energy savings than others and how this influences some, but not necessarily all of their habits, we have selected 10 families for qualitative interviewing. The 10 families consist of 6 relatively high income and 4 relatively low-income families, 5 of which consider themselves careful about saving energy ("savers") and the other 5 who do not think of themselves as careful about saving energy ("spenders"). The 10 families can be grouped into four types:

- low income, "savers" (with low levels of electricity use: 1600-1700 kWh)
- 3 high income, "savers" (with low levels of electricity use: 1800-3300 kWh)
- 2 low income, "spenders" (with high levels of electricity use: 6000 -7000 kWh)
- 3 high income, "spenders" (with high levels of electricity use: 4600- 8700 kWh)

Two aspects of this analysis are considered in this context: 1) Reasons for being a "saver" or a "spender", and 2) Which energy practices are actually affected by this attitude.

Peter is one of the high-income spenders. He is an engineer fascinated by technological solutions and enjoys having a lot of space, so he lives with his family in a very big house with many appliances, and he thinks one should enjoy life instead of focusing on saving[5]. For him there is really no reason for saving energy as his private economy is sound, he considers environmental problems to be questionable and might be solved by new technologies. His own explanation on how he became a spender is: "That is what happens when you earn enough money". At the very opposite end, we find Elisabeth who is a low-income saver. However, her primary reason for saving is not economy but ecology. She enjoys living in a quite small house without too many unnecessary appliances and she thinks she and her son have a rich life. She explains that sometimes she is too much of a saver and thus denies herself some pleasures, including not buying the lamps she finds most beautiful but prioritizing those that are suitable for CFLs. Her explanation for being a saver is coupled both to an upbringing with a tight economy and to her experiences with health and alternative medicine leading her to hold an ecological world view. Other families are not that easy to categorize. All three high-income savers for instance emphasize that they might be savers in relation to energy use, but they are certainly not savers in relation to all other aspects of their lives: They do not deny themselves quality food or wine or think of saving on entertainment and traveling. On the other hand some of the spenders, both high and low income, are actually a bit ambivalent, because they think they ought to save more than they do, either for reasons of economy or ecology. As a high-income spender, Anders, expresses: "You ought to, but what the hell, others don't do it either!" And he continues: "If I have to choose between comfort and saving energy, then I choose comfort". In general the spenders state that the problem is that in daily life questions of comfort, convenience or time-saving often weigh more heavily than their interest in energy saving. Some savers also express this ambivalence. Hanne, a high income saver, says about her tumble dryer: "Really, I work outside the home, and I think we should use energy with consideration, but I also think that we should try to make our everyday life hang together, and there it (the tumble dryer) helps me". However she primarily uses the tumble dryer in wintertime. In general the savers more than the spenders do not think that the way they save energy actually affects their comfort and convenience or that it is very time-consuming.

What practices are then actually connected with a households' carefulness in energy saving? For all the respondents, A-labels[6] of refrigerators and freezers are strongly related to energy savings. Most of the interviewees do actually buy A-labeled appliances, and even those who do not (some of the spenders), reflect on why they did not (for instance because of a special design etc.). Also "turning off the light" seems to be well established in the mind of all the households as an energy saving activity, including those who do not actually practice it. One interesting finding is that even among households using less than 15% of their total electricity

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[5]All names are changed to ensure anonymity of the interviewees
[6]A-label refers to an obligatory European energy label system, where A signifies the most energy efficient.

consumption for lighting "turning off the light" seems to be the one energy saving activity that the households are most aware of. The question of standby is unclear. Some households actually turn off standby without being particularly aware of it as an energy saving activity, but because they find it more convenient (for instance if more appliances are used together on the same switch) or because of fear of spontaneous ignition in televisions causing fire. Other households may know about electricity waste caused by standby but find it difficult to remember to turn it off. A man explained how he was very much aware of turning off the light. For instance he told how he had called his wife from the mobile phone one morning after he had left home to tell her to remember to turn off the light on the second floor, as he had forgotten to do so. At the same time however they have five computers with different accessories, which are always on standby, so they actually use much more electricity on standby (17%) than on light (10%). The man was intellectually aware of this paradox and reflected on it, however it had not until now changed his habits. A possible explanation seems to be time. Ever since his childhood the question of turning off the lights had been an issue, so even though they now use CFLs in many lamps, he had this reflex regarding the light built into the body, so to speak. The question of turning off standby on the other hand has only been known for a few years. It was something he was intellectually aware of but not something that had become integrated in his daily activities.

The last aspect included in this context concerns how much the different appliances were used. Other studies (Gram-Hanssen 2002, Shove 2003) have shown that the amount of laundry varies with many other things than the amount of dirty clothes. In general the amount of clothes washing is growing. In spite of this only one of the families associated the question, when clothes are put to wash, with energy use. Even though many families use as much energy on washing and drying as they use on lighting, very few of them (both spenders and savers) consider whether the clothes actually need washing. In general the interviews showed a fairly low correspondence between the actual distribution of electricity on end-uses and the families focus on energy savings.

Conclusions

As described in the introduction, lifestyle can be understood simply as patterns of activities, or these patterns of activities can be seen together with possessions and attitudes. The concept of lifestyle can also include explanations of how the patterns of activities and attitudes are related to the social structure of society and incorporated in a bodily habitus already from our childhood. All three concepts of lifestyle can be relevant in explaining energy consumption and in all three concepts the question of how socio-economic background-variables influence energy consumption can be interesting.

In this paper we have shown that the total electricity consumption in a household is highly dependent on income and the floor area of the dwelling, whereas age and especially education, gender and ethnicity seem to have very little influence. Regarding the distribution of electricity consumption on different end-uses, both income and age influence some, but not all of the end-uses. Electricity use for refrigerators/freezers and televisions seems independent of both age and income, whereas dishwashing, washing/drying, lighting and standby depend both on age and income, whereas computers depend on income but not on age.

Background variables however can only describe 30-40% of the variations of the electricity consumption of households. Whether the household is careful about saving energy can further explain some of the variation. Carefulness in saving energy may depend on a need for

saving money, on deep-rooted habits dating from childhood or on a conscious wish of acting environmentally friendly. In this way the interviews demonstrate that understandings of lifestyle associated with values and attitudes as well as with unconscious bodily habitus may be relevant in the understanding of energy use.

Our findings demonstrate that actual behavior cannot be understood in a simple rational model where a wish to save energy actually leads to changed behavior. For instance, in most families lighting gets much more attention than the end-use of washing or standby even though some families actually use quite a small share of their total electricity consumption on lighting. And this is so even though these families actually have been told how their total consumption is distributed on end-uses. In this way the interviews demonstrate how daily habits and routines in many cases are changed only very slowly in spite of information and campaigns. However, the interviews also show that other people actually do manage to keep a fairly low level of electricity consumption grounded in a conscious attitude toward energy savings.

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