Factors influencing residents' energy use

- A study of energy-related behaviour in 57 Swedish homes

Author: Carolina Hiller, carolina.hiller@sp.se, SP Technical Research Institute of Sweden

Abstract

The aim of this work has been to study everyday energy-related behaviour in homes. All residents in 57 Swedish homes, living in three housing areas, have recorded time diaries over a period of four days, during the same time period in each area. The technical differences between the houses are limited, as the building designs within each housing area are the same. On an aggregated level, the diary data has been analysed with and without typical power data of appliances as well as in relation to measured total energy use, indoor temperature and water usage. Cluster analyses have been performed in order to find characteristics of groups of residents with regard to their energy-related behaviour. Some of the findings were that residents report long time use/operating time for activities related to electronic equipment (45 % of total reported time). Residents which used energy to a greater extent than others were characterised by performing activities with long operating times, in combination with high, and fairly high, typical power ratings. The majority of residents showed many different energy-related behaviours, which indicates that a number of strategies to influence the behaviours - not just one - will be required.

Keywords: Energy-related behaviour; residents; time use; diary; energy measurement; cluster analysis

1. Introduction

On the global level, the residential sector dominates energy use in the building sector, with use having increased by 32 % between 1990 and 2009 (measured in joules) [1]. The equivalent figure for OECD countries is 18 %. This includes a rapid increase in electricity use in all regions. At the same time, world population is increasing, and the number of households is predicted globally to grow even more, as there is a trend of fewer persons per household. Larger floor area per household is another trend in the residential sector [1].

Improved energy efficiency is one of the most important ways of reducing the negative effects of these trends, and has been so over the past decades. The energy-related behaviour of households plays an important role in realising energy-efficient measures in an effective way. This behaviour can be related to implementation and

acceptance of new technology, maintenance of equipment and the use of energy. To a great extent, energy-related behaviour influences the gap between potential and actual energy efficiency levels [2].

Households’ energy-related behaviour can be categorised as illustrated in Figure 1, with different kinds of behaviour sorted by frequency and cost. It can be seen that some improvement actions occur relatively infrequently, such as replacing traditional light bulbs with low-energy bulbs or installing new seals around windows and doors. Such measures are relatively inexpensive, but their effect can be significant. Other decisions relate to more substantial improvements, usually with higher costs, and need more consideration. Examples include the purchase of refrigerators and freezers, televisions, computers or new heating systems. These purchases are usually made when the old equipment is worn out and discarded. Then there are habits and behaviours that occur on a daily basis and that often become routine. Small changes in daily activities can eventually make a big difference in energy use, often with no cost associated with these changes. Examples of this type include how laundry is dried or for how long people take in a shower. This article is mainly concentrated on these daily activities. Strategies to influence energy-related behaviour should be designed with these categories in mind [2, 3].

	Infrequent	Frequent
No/low cost	Stocktaking behaviour Energy-efficient lighting (e.g. LED) Temperature set backs Draught proofing	Habitual behaviour and lifestyles Turn off computer and other devices Air-dry laundry Take short showers Use energy-efficient washing programs
Higher cost /investment	Consumer behaviour Energy-efficient white goods/ appliances Energy-efficient windows Additional insulation Heat pumps	

Figure 1 Households’ energy-related behaviour, focused on some examples in single-family houses [3]

It is generally difficult to put a specific figure on the potential savings from changed energy-related behaviour. A general estimate, often seen, is approximately 20 percent - however, the reference for this figure is not completely clear. In an American study, a number of common energy-saving actions related to behaviour in the ‘No/low cost’ category amounted to potential savings of approximately 12 percent [4]. In another American study, the savings are estimated to similar figures, but included transportation behaviour as well [3]. Older studies, e.g. Palmborg [5], estimate the potential savings of total energy use to be about 10 percent. Various studies also show great variations between similar houses that cannot be explained by technical differences alone; energy behaviour is thought to contribute to the substantial differences [6-15].

This paper is part of the overall "Energy use in single-family houses - The significance of residents' behaviour" project, where 57 households participated in a diary study of everyday behaviour. The diaries recorded the time used for everyday activities in the households. In parallel with the diary keeping, energy use in the houses was measured. The overall goal is to use the knowledge derived to contribute, long-term, to the reduction of energy use in the residential sector. This paper focuses on the results from the diary study, and relates these data to measurements of total energy use in the participating households. The objective is to find out what kinds of activities characterise households' energy use. In [15] details of the measurements are presented including households' energy use, indoor temperature and water use as well as load profiles.

Time diaries have been used and analysed in other studies, particularly in projects related to people's everyday behaviour conducted by Kajsa Ellegård and colleagues at Linköping University in Sweden [16-19]. However, few studies have linked energy-related behaviour with direct measurements of energy use. There are examples of studies that have combined measurements and diaries with a focus on a few activities, such as dishwashing habits [20] or lighting patterns and presence in offices [21]. There are also examples of smaller studies where hot water usage as well as electricity usage in households have been studied together with diaries in order to identify usage and load patterns visually [22, 23]. Other studies use national time-use data for modelling household profiles or to develop and validate models, e.g. [24-31]. There are also studies that relate time use data or diary notes to energy issues [18, 32-34] and water consumption [35-37]. However, there is a lack of larger studies which connects actual behaviour with energy measurements. There are many questions to be answered regarding the residents and their activity patterns associated with energy use. Trying to describe and explain the residents' influence is important for energy planning and in order further to study different types of behaviour profiles. The project mainly complements previous studies, in which only a few households have participated, and focuses on differences between households where the construction and building services systems of the houses are similar.

1.1. Research objectives

The objective of this paper is to find characteristics of energy use in houses. How and in what way the energy use differs between different households in similar houses is specifically highlighted. The paper is focused on explanatory factors related to family composition, behaviour and other household-related factors.

1.1.1. Research questions

Questions that will be answered in this paper are:

1. What everyday energy-related behaviour is performed in homes? And for how long?
2. Can common characteristics be identified between different types of consumers?

1.2. Limitations

The main limitations of the study are:

- Only houses built on housing areas with several similar houses are included.
- Only total energy used is measured.
- The measurements are made during three different periods for the three housing areas.

2. Material and methods

2.1. Houses and residents

The three groups of houses included in the project were considered to represent "common houses", all built in the 1980s. Electrically-heated detached houses were chosen, so that their energy use would be easy to measure and could be associated with each individual home. Within each housing area, the houses were nominally built in the same way - thus the households' energy use could be compared without having to take the buildings' design into account. The houses are further described in [15].

57 households living in the three housing areas participated in the study. In total, the households comprised 171 family members, whereof 134 were 12 years old or above, and were asked to write individual diaries. In the end, 141 persons wrote diaries for four successive days (a number of children younger than 12 wanted to participate and two couples wrote only one diary instead of two individual diaries), which means 564 diary sheets were completed (four days and nights).

Table 1 shows the different types and numbers of households based on family composition. The categorisation is based on the report "End-use metering campaign in 400 households in Sweden – Assessment of the potential electricity savings" [38]. It should be clarified that the category "Families" includes couples with one or more

children as well as a single parent with one or more children. In a few cases, households do not belong to one of the stated categories.

Table 1 Categories of participating households

Household types		Housing area			Sum
		A	B	C	
I	Single persons, 26-64 years	1	0	0	1
II	Single persons, 65 years and above	0	0	0	0
III	Couples without children, 26-64 years	7	3	4	14
IV	Couples without children, 65 years and above	0	5 ^a	0	5
V	Families	14	11	12	37
Total number of households		22	19	16	57
Total number of persons		66	52	53	171

^a One couple has been categorised as Household Type IV, although they are not 65, because they are close to retirement age and because one person in the household is retired (disability pension) and the other person was unemployed at the time of measurement.

One “single-person” household and five retired couples are represented in the project. The majority of households were families. The distribution of households in each type is similar to that in [38].

2.2. Measurement period

The study was conducted over four days during the heating season. In order to study energy use covering both weekdays and weekend days, the measurements and time diaries were carried out from Wednesday evening to Sunday evening. The study was run during three different periods in each housing area: namely in November 2005 in housing area A, in December 2005 in area B and in February 2006 in area C.

2.3. Time diaries

The diary used was designed as a structured diary, with headings as shown in Table 2. The headings were decided on after investigating previous time use studies [19, 23].

Table 2 Diary sheet used in the study (translated)

Time start	Time end	What am I doing?	Use of equipment, lighting or hot water - Household appliances - Lamps (including number of lamps) - Other electronic equipment - Regulating temperatures (radiators) - Hot water usage - Etc.	Where? - which room in the house - garage - storage - garden	Comments

The instructions were to write down everyday activities carried out while at home, and to do this over the course of the four days. This meant that each individual has recorded what activities they performed, how and when. Younger children's activities were recorded in their parents' diaries.

2.4. Measurements

While the participating residents kept diaries, each household's total energy use was measured continuously. The indoor and outdoor temperatures were recorded every hour during the four days. In addition, each household's water use was registered. The results from the measurements, including load profiles, are described in more details in [15].

2.5. Procedure

The approach, and specifically the use of time use diaries, is based on a number of sources, such as Ellegård and Wihlborg [19], Sernhed [23], Eurostat [39, 40], Rydenstam and Wadeskog [41], and Japac et al. [42], Ellegård and Nordell [16], Sommer and Sommer [43], U.S. Census Bureau [44, 45] and discussions with Statistics Sweden's Mikael Molén [46].

A number of steps were taken with the intention of improving the response rate and the quality of the study. They included introduction letters, phone calls and home visits in order to inform residents about the project, to ask for participation and to give instructions. During a first home visit, instructions were given orally and in writing to as many family members as possible. An example of an already filled-in diary was shown.

Confidentiality was guaranteed for the participants and each person was given an individual code. Two additional home visits were made prior to the measurement period to install temperature sensors and to read the water meters. Before the diary study was started, the instructions and the diary sheets were tested on a number of persons of different ages to see if the method and the directives were user-friendly. After the diary study, the participants were asked during a final home visit to give additional information about their house and household, and also to discuss any uncertainties in the diaries.

2.5.1. Processing of diaries

The diary notes were sorted and categorised using a number of variables, representing certain energy-related behaviours. For each variable, the total time spent doing the activity for the whole household (i.e. all family members) was entered. For certain activities, the number of times that the activity was carried out was given instead, i.e. the frequency.

The variables were categorised under certain themes, related to previous literature (e.g. [47]). The themes were Cooking/Kitchen, Personal Hygiene, Clothes Care, Comfort and Electronics. There were also 'Others' and 'Presence at Home' categories. All uncertainties and missing values in the diaries were well documented and thereafter assessed and dealt with in a systematic way. Missing values were handled by using valuable information given at the home visits or by estimates from previous occurrences. In some cases, the uncertainties or gaps in the diaries were left and no data was filled in. This processing was carefully noted. Additionally, there were certain activities/information that could not be processed as the data quality was poor: these include lighting, stand-by electricity use and other constantly-plugged-in electronic devices, use of fireplaces, visits to toilets, etc.

It should be noted that in this paper the term 'Time Use' is used as a general term for the data derived from the diaries. In some cases, a more correct term would be to refer to the 'Operating Time' of appliances.

2.5.2. Interrater reliability test

An interrater reliability test was performed in order to evaluate interpretation of the diaries. The ordinary rater instructed the test rater in the procedures of interpreting the information in the diaries. Five cases have been tested and evaluated. The correlations of the results from the two raters were calculated using ReCal, which is an online interrater reliability web service¹. The correlation values were in the range of 0.57-0.83 (Krippendorff's alpha [interval])². This corresponds to agreements of 32-69 % between raters. These percentages are satisfactory, meaning that the interrater reliability is acceptable, although the lowest value of 32 % indicates only moderate agreement. The other values indicate substantial agreements.

¹ ReCal can be found at <http://dfreejon.org/utills/recalfront/> (October 2011)

² Krippendorff's alpha (interval) [48]

2.5.3. Forming groups - Cluster and other analyses

A general description of the diary data has been compiled and presented for the three complete days - Thursday, Friday and Saturday. Cluster analyses were then performed in order to group residents according to their energy-related behaviour and explore similarities within a group as well as dissimilarities between groups. Data were used from 21:00 on Wednesday to 17:00 on Sunday.

In a first step, a hierarchical clustering was applied using Ward's method with the measure of Euclidean distances. In a second step, a K-means cluster method was used to see if the suggested hierarchical cluster solution could be improved. As the data for the different variables differ greatly the analyses were performed twice; once with non-standardised values (no data preparation), and once with transformed values to a standardised scale (by z-scores). In a third step, one-way analysis of variance (ANOVA) was carried out in order to examine how the clusters differ. In addition to the 44 variables listed in Table 5, total measured energy use and energy groups (described below) were also tested. In a final step, the effects of background factors (here, housing areas and household types) on the cluster solutions were tested by performing chi-squared tests. The IBM SPSS Statistics (Version 21) software was used for the statistical calculations.

This procedure was then repeated for estimated energy data, which was obtained by using the diary data and converting this data to energy use by using typical power values and formulas, found in a number of Swedish references, such as [23, 49-53].

Most of the variables previously tested were also included in this analysis. Exceptions were the use of printers (no power data found for actual usage, only standby mode) and washing clothes by hand. In addition, the Presence at Home, Number of Persons, Indoor Temperature and Water Use data variables were not converted to a standard energy use; they were tested separately for the suggested cluster solution.

Finally, another grouping was constructed from the energy usages of the households. The households were divided into three groups - Low (1), Medium (2) and High (3) consumers - based on a frequency analysis, where quartiles, median and typical values of energy use were considered. The sizes of the groups were roughly the

same. This was done separately for each housing area, as the energy use had not been adjusted for different outdoor temperatures.

3. Results

3.1. Compilation of diaries - obtained time use for different behaviours

Frequencies and averages are presented for a number of activities, which means a description of what energy-related behaviours are carried out and for how long (expressed in hours or minutes per day). Most of the data are presented as averages per household.

3.1.1. Time spent at home

The daily average time spent at home per person was 14.9 hours on Thursdays and Fridays. On Saturdays, the corresponding figure was 17.8 hours. Considering an entire week, the estimated presence at home was therefore 15.7 hours per day.

3.1.2. Overall time use data related to energy use

Figure 2 Daily time use related to energy use for an average household, illustrated as total time use summed up for all appliances turned on or all activities performed. Data derived from diaries and expressed in hours. Shown for different categories of variables for three complete days - Thursday, Friday and Saturday.

Figure 2 shows that the usages differed for the different days for the various categories (activities included in each category are listed in Table 5). There is an increase in activities on Saturday for all categories except for

the Others category, where it was the opposite, having the most activity on Thursday instead. Fridays usually had fewer reported activities than Thursdays.

In Table 5, averages for a number of activities given in the diaries are listed. As can be seen, there were activities that were performed by several households. Others showed very low values, as they were performed for very short times and/or were performed by few households. Activities belonging to the Electronic category are illustrated in more detail in Figure 3.

Figure 3 Daily time use related to energy use for an average household, illustrated as total time use summed up for all appliances turned on. Data derived from diaries and expressed in hours. Shown for different variables for the Electronics category for three complete days – Thursday, Friday and Saturday (note different scale compared to Figure 2).

Figure 3 shows that TV use was the dominant activity, mostly on Saturday, followed by Thursday and Friday.

Other activities with long usage, included the use of computers, followed by stereo/radio. This equipment can be turned on for long periods without really being actively used all the time.

Table 5 shows detailed data for the other categories. It can be seen for the Cooking/Kitchen category that fans were the devices used for the longest time. As far as differences between days are concerned, the use of cooking stoves on Saturday stand out in comparison with stove usage on Thursday and Friday. Not much time was reported on activities to do with Personal Hygiene. Taking a shower was the most frequent activity related to Personal Hygiene. The opening of windows (airing) was one comfort-related activity that could be based on information from the diaries, but unfortunately this activity was irregularly reported. The time spent on Clothes

Care that was related to energy was little in comparison with other activities. The tumble dryer was the appliance used the most, together with the washing machine. Finally, it can be seen that a substantial amount of time was spent on variables in the Others category.

3.2. Cluster analyses and ANOVA

The following cluster solutions are described in this section:

- Cluster solution with diary data (standardised values in minutes)
- Cluster solution with diary data (non-standardised values in minutes)
- Cluster solution with diary and power data (standardised values in Wh)

Last, a grouping based on low, medium and high energy use is presented.

3.2.1. Cluster analyses of diary data – using standardised and non-standardised values

Three cluster solutions were identified, both in case of using standardised (Cluster 1_s - Cluster 3_s) or non-standardised (Cluster 1_n - Cluster 3_n) values, further specified in Table 3. Note that two of the households were not included, as their water usage data were incomplete.

Table 3 The characteristics of cluster solutions with standardised and non-standardised of diary data values

Table 5 The characteristics of cluster solutions with standardised and non-standardised of diary data values												
Cluster solutions		No. of households	Average no. of persons	Household types (no. of households)					Housing areas (no. of households)			Average indoor temperature (°C)
				I	II	III	IV	V	A	B	C	
Standardised	Cluster 1 _s	18	2.2	1	0	7	3	7	7	6	5	20.7
	Cluster 2 _s	29	3.5	0	0	3	2	24	11	12	6	20.7
	Cluster 3 _s	8	3.3	0	0	2	0	6	2	1	5	21.0
	SUM	55	-	1	0	12	5	37	20	19	16	-
Non-standardised	Cluster 1 _n	24	2.1	1	0	12	5	6	8	10	6	20.5
	Cluster 2 _n	23	3.5	0	0	0	0	23	10	7	6	20.8
	Cluster 3 _n	8	4.5	0	0	0	0	8	2	2	4	21.1
	SUM	55	-	1	0	12	5	37	20	19	16	-

The results for the analysis of variance are listed in Table 6 - both for standardised and non-standardised values. 17 and nine of the 44 tested variables showed significant differences between the clusters ($p\text{-value} \leq 0.05$). Presence at home, number of persons in the household and water usage (in litre/household, day) were variables that were significant in both the standardised and non-standardised analysis.

ANOVA results also showed that energy use differed between the clusters with the standardised values (p -values ≤ 0.05). This concerns both the total energy use - uncorrected for different outdoor temperatures (with values of 2.9 kWh/m² for Cluster 3_s, compared to 2.2 kWh/m² for both Cluster 1_s and Cluster 2_s) - as well as the three groups of Low, Medium and High usage (with Cluster 1_s having an average group value of 1.7, 1.8 for Cluster 2_s and 2.6 for Cluster 3_s). It was found that the average usage was higher for the eight households of Cluster 3_s. These households have reported a higher use of engine preheaters, electric clocks, fans, hair tongs, sewing machines and airing and hand-washing of dishes than the rest (Table 6). A number of activities included in the Others category were also performed by some of the households in this cluster, e.g. the usage of electric jigsaws, sandwich toasters, and extra electric radiators that were turned on constantly. As can be seen in Table 3, these households consisted, on average, of 3.3 persons per household, and many were families. They had an average indoor temperature of 21.0 °C.

The households of Cluster 1_s showed much lower values for presence at home, number of persons in the household and water usage (in litre/household, day) than the other two clusters (Table 6).

Energy use did not differ between the clusters with the non-standardised values (p -value > 0.05). The households of Cluster 3 stood out as the cluster with generally longer usage time for a number of variables such as the use of TV, computer, electric kettle and dishwasher (Table 6). These households also spent longer time on average on washing dishes by hand. Moreover, they spent more time at home (presence), they consisted of a greater number of persons per household, and they had higher water usage (in litre/household, day).

With regard to the background factors of housing area and household type, no significant differences between the clusters were shown for the standardised solution according to the chi-squared tests (p -values > 0.05). For the non-standardised solution, significant differences were found for household types (p -value < 0.05), but not for housing area. Table 3 shows household types.

3.2.2. Cluster analysis of diary data and typical power values – using standardised values

A three cluster solution was found using standardised power values (Cluster 1_{p,s} - Cluster 3_{p,s}), further specified in Table 4. The analysis with non-standardised values gave no relevant clusters.

Table 4 The characteristics of cluster solution with standardised values of diary data and typical power values

Cluster solutions		No. of house-holds	Average no. of persons	Household types (no. of households)					Housing areas (no. of households)			Average indoor temperature (°C)
				I	II	III	IV	V	A	B	C	
Standardized	Cluster 1 _{p,s}	30	2.6	1	0	10	4	15	14	9	7	20.6
	Cluster 2 _{p,s}	20	3.6	0	0	2	1	17	6	10	4	20.9
	Cluster 3 _{p,s}	7	3.3	0	0	2	0	5	2	0	5	21.1
	SUM	57	-	1	0	14	5	37	22	19	16	-

The results of the ANOVA are shown in Table 6. Twelve of the 36 tested variables showed significant differences between clusters ($p\text{-value} \leq 0.05$). These were TV, car engine preheater, car heater, kitchen fan and other fans, food processor, airing, floor heating, tumble drier and sewing machine. In addition, three variables belonging to the category of Others showed significant differences. Seven of these twelve variables showed a higher average for Cluster 3_{p,s} (Table 6). This meant that there was a small group of households (7) that had a substantially higher average usage of energy for heating their cars before driving (car heater and engine preheater), turning on fans and habits of airing. In addition, some of the households in Cluster 3_{p,s} used jigsaw, electric hedge trimmer, sandwich toaster, sauna and extra radiator, included in the Others category. In addition, the Presence at Home, Number of Persons and Water Usage (in litre/household, day) variables were significant for this specific cluster solution, where Cluster 1_{p,s} stood out with much lower values on average compared to the other two clusters.

The cluster solution differs regarding energy use - the variance analysis showed significant differences between the clusters ($p\text{-values} \leq 0.05$). This regards both the total energy use - uncorrected for different outdoor temperatures - (with values of 2.2 kWh/m² for Cluster 1_{p,s}, 2.3 kWh/m² for Cluster 2_{p,s} and 3.1 kWh/m² for Cluster 3_{p,s}), as well as the three groups of Low, Medium and High usage (with Cluster 1_{p,s} having average group values of 2.2, 1.6 for Cluster 2_{p,s} and 2.6 for Cluster 3_{p,s}). Cluster 3_{p,s} had the highest average usage.

With regard to the background factor of housing area, the chi-squared test ($p\text{-value} < 0.05$) showed significant differences for this cluster solution. Table 4 shows the distribution regarding housing area. On the other hand, the household types did not show any significant differences between clusters.

3.2.3. Grouping of Low, Medium and High usage

The variance analysis showed that only the usage of food processors differed between Low, Medium and High consumers, both for standardised and non-standardised values (p -value < 0.05).

4. Discussion

4.1. Residents' energy-related behaviour

The main findings of the studied residents' daily energy-related activities are that the appliances / activities that belong to the Electronics category account for the greatest time use (45 percent of total reported time), of which using the TV is the most common activity. It can also be seen that for most energy-related activities there is an increase in time use during the weekend compared to week-days. Personal Hygiene and Clothes Care are those categories on which less time is spent with regard to energy-consuming behaviour.

4.2. Typical activities of energy consumers

The main findings of the cluster analyses are here discussed. Based on diary data on time use or operating times, the eight households that have a higher average energy use are characterised by spending more time or longer operating time on car engine preheaters, airing and having extra electric radiators - to mention the activities using the most energy (referring to the solution Cluster 1_s - Cluster 3_s with diary data and standardised values in minutes).

Although there seems to be some influence of to which housing area the households belong, it can be seen, based on estimated energy data, that the seven households having a higher average energy use are characterised by using more energy on engine preheaters, car heaters, fans, airing and additional radiators than the other households on average. One can further see that these activities generally have long operating times, in combination with high power ratings (referring to the solution Cluster 1_{p,s} - Cluster 3_{p,s} with diary and typical power data with standardised variables in Wh). It can be added that six households belonging to Cluster 3_s and Cluster 3_{p,s} are identical.

In addition, presence at home, number of persons in the household and water usage (in litre/household, day) are variables that stand out as characteristics of certain groups. Particularly those with lower values for these

variables stand out (Cluster 1_s and Cluster 1_{p,s}). However, this is not clearly shown as the reason for low energy use.

4.3. Comments on the method used

Self-reported methods, such as diaries, are characterised by the fact that writers of the diaries will document what they think to be relevant, which will vary from person to person. There is therefore subjectivity in the actual data collection. The level of details given in the diaries also varies. The diversity of energy-related activities can be hard to capture and report in a diary format. One example is lighting, which can be of significance³. To minimise any obstacles of writing or misunderstandings, simplicity is prioritised in the design of the diary. If the diary study was to be repeated today, the use of digital tools would have been considered.

The question of standardising data or not has to be considered for data sets where variables that are to be compared are of different magnitudes or have very different variations. To use standardised scales can even out these differences. However, the drawback is that some variables can be given too much weight in the analysis. For that reason, analyses were made using both standardised and non-standardised values.

4.4. Application of the results

The study was performed over four days. In order to represent “normal days”, a large number of households participated in the study, with the result that exceptional circumstances have lesser effect on the results than would be the case if only a few households had participated. To gather variations in activities over time, a large number of days would be preferable. However a greater number of days do not automatically mean more reliable data [54]. It is generally considered that a great number of days will decrease the quality of the diary data (less details and less accuracy) as the burden for the participants increases, leading to that the motivation decreases and hence the risk for non-response increases [40, 43, 55]. For large national time use surveys, two days are recommended and considered reasonable [40]. In this study a four day approach was chosen to gather enough information but without jeopardizing the response rate.

³ In a Swedish end-use electricity metering campaign, including 199 single-family homes, electric lightning accounted for on average approximately 8 % of the total energy use of the households [38]

Although the houses in the study were not randomly selected, they can represent modern average houses, built in the 1980s after the Swedish building regulations on energy use came into force after the oil crisis 1973-74. It should be noted that when a certain type of similar houses on housing estates is studied, socio-economic and demographic aspects may come into the picture.

4.5. Comparison with other studies

In the Introduction section some studies that use time use data were mentioned. However, it is difficult to compare the results from the different studies, as they have different objectives and perspectives and present the results in different ways. e.g. in Nordell [32], time use data is presented for two days and per person, and other activities in addition to energy-related activities are included. In addition, there are the large national time use studies performed in different countries [56]. The focus of these studies is on how people use their time in general, which is a much wider perspective than the focus of the present study.

To include two comparisons of “isolated” activities, one comparable figure can be mentioned related to airing, which was found in [57]. In this project, the options and potentials of energy diaries were studied, which includes investigating activities such as airing. The average number of times windows are open is 1 hour and 30 minutes per day (on average, five windows per day). A remarkable difference in behaviour between the participating households is also noticed. In the present study the comparable figure is approximately 1 hour and 40 minutes per day, although it must be borne in mind that this activity is irregularly reported.

The other comparison that can be made is for the daily estimated amount of time spent at home, which in this study is 15.7 hours on average. This is similar to results in previous Swedish and international studies, with results of 15.6 h/day in Sweden [58], 15.7 h/day in Germany [59], 15.6 h/day in the USA [60] and 15.8 h/day in Canada [60]. This indicates that there is a certain extent of validity to the results of this study.

5. Conclusions

The main conclusions from the paper are:

- Regarding everyday energy-related behaviour, residents report on long time use/operating time for activities related to electronic equipment, such as the use of TV.

- More time is spent on energy-consuming activities in homes during the weekend than during weekdays.
- Activities with long operating times, in combination with high (and fairly high) power ratings, are typical for residents which use energy to a larger extent than other residents. This includes the use of engine preheaters, car heaters, fans and additional radiators, as well as airing habits.
- Those residents that on average spend less time at home and that have on average a smaller number of family members, also show a lower water usage (measured per household) on average. The study indicates that these are characteristics of households that can differentiate greatly between households.

This study has identified a number of characteristic behaviours of, primarily, those residents that use the most energy. However, this relates to a limited number of households. For the rest of the households, there are a number of activities that decide their energy use which could not clearly be pointed out. This indicates that there will also be a need for a number of strategies - not merely one solution - to influence energy-related behaviours.

Acknowledgements

The work is part of the “Energy use in single family houses - The significance of residents’ behaviour” project, which is a multidisciplinary project carried out in collaboration between the Departments of Building Physics (Professor Jesper Arfvidsson and Professor Emeritus Arne Elmroth) and Environmental Psychology (Docent Thorbjörn Laike), both at Lund University, Faculty of Engineering, LTH, and the Department of Energy Technology at SP Technical Research Institute of Sweden (Ph. D. Ingemar Samuelson and Svein Ruud). I would like to thank all of the above-mentioned supervisors for their great support. Further, I express my sincere gratitude to all the homeowners who participated in the project. It has been incredibly generous of them to open their homes so that the measurements could be carried out. The project is funded by the Swedish Research Council Formas, Region Västra Götaland and SP.

References

- [1] International Energy Agency, Energy Technology Perspectives 2012. Pathways to a Clean Energy System. 2012, OECD/IEA: Paris.
- [2] International Energy Agency, Energy Technology Perspectives 2010. Scenarios & Strategies to 2050. 2010, OECD/IEA: Paris.
- [3] Laitner, J.A.S., Ehrhardt-Martinez, K., and McKinney, V., Examining the scale of the Behaviour Energy Efficiency Continuum, in eceee 2009 Summer Study. Act! Innovate! Deliver! Reducing energy demand sustainably. 2009: La Colle sur Loup, France.
- [4] Gardner, G.T. and Stern, P.C., The short list - The most effective actions US households can take to curb climate change, in ENVIRONMENT. 2008. p. 12-25.

- [5] Palmborg, C., Social habits and energy consumption in single-family homes. *Energy*, 1986. 11(7): p. 643-650.
- [6] Lundström, E., Boendevanornas inverkan på energiförbrukningen i småhus. 1982, The Swedish Council for Building Research: Stockholm, Sweden.
- [7] Gaunt, L., Household and energy - the influence of everyday habits on energy consumption in Swedish single family houses. 1985, The National Swedish Institute for Building Research: Gävle, Sweden.
- [8] Socolow, R.H., The Twin Rivers Program on Energy Conservation in Housing: Highlights and Conclusions. *Energy and Buildings*, 1977/78. 1: p. 207 - 242.
- [9] Statens Offentliga Utredningar, Utredning angående värmekostnaden i hyreshus – Betänkande avgivet av Värmekostnadssakkunniga. 1942, Socialdepartementet: Stockholm.
- [10] Hirst, E., Goeltz, R., and Carney, J., Residential energy use analysis of disaggregate data. *Energy Economics* 1982. 4(2): p. 74-82.
- [11] Pratt, R.G., Conner, C.C., Cooke, B.A., and Richman, E.E., Metered end-use consumption and load shapes from the ELCAP residential sample of existing homes in the Pacific Northwest. *Energy and Buildings*, 1993. 19: p. 179-193.
- [12] Gill, Z.M., Tierney, M.J., Pegg, I.M., and Allan, N., Measured energy and water performance of an aspiring low energy/carbon affordable housing site in the UK. *Energy and Buildings*, 2011. 43(1): p. 117-125.
- [13] Nylander, A., Johansson, P., and Johnsson, F., Towards sustainable buildings: A survey on potential improvements of the existing building stock, in CIBW70 2006 Trondheim International Symposium, Changing User Demands on Buildings. 2006: Trondheim.
- [14] Sonderegger, R.C., Movers and stayers: The resident's contribution to variation across houses in energy consumption for space heating. *Energy and Buildings*, 1978. 1(3): p. 313-324.
- [15] Hiller, C., Influence of residents on energy use in 57 Swedish houses measured during four winter days. *Energy and Buildings*, 2012. 54: p. 376-385.
- [16] Ellegård, K. and Nordell, K., Att byta vanmakt mot egenmakt. 1997, Johansson & Skyttmo Förlag AB: Stockholm.
- [17] Ellegård, K. and Cooper, M., Complexity in daily life—a 3D-visualization showing activity patterns in their contexts. *electronic International Journal of Time Use Research*, 2004. 1(1): p. 37–59.
- [18] Green, A. and Ellegård, K., Consumer behaviour in Swedish households: routines and habits in everyday life, in ECEEE 2007 SUMMER STUDY. 2007.
- [19] Ellegård, K. and Wihlborg, E., eds. Fånga vardagen. Ett tvärvetenskapligt perspektiv. 2001, Studentlitteratur.
- [20] Richter, C.P., Usage of dishwashers: observation of consumer habits in the domestic environment. *International Journal of Consumer Studies*, 2011. 35(2): p. 180-186.
- [21] Maleetipwan-Mattsson, P., Laike, T., and Johansson, M., Self-report diary: A method to measure use of office lighting. *LEUKOS - Journal of Illuminating Engineering Society of North America*, 2013. 9(4): p. 291-306.
- [22] Karlsson, K. and Widén, J., Hushållens elanvändningsmönster identifierade i vardagens aktiviteter. 2008.
- [23] Sernhed, K., Effekten av effekten – Elanvändning och laststyrning i elvärmda småhus ur kund- och företagsperspektiv – Fallstudier, in Avdelningen för Energihushållning, Institutionen för Värme- och Kraftteknik. 2004, Lund Universitet: Lund.
- [24] López-Rodríguez, M.A., Santiago, I., Trillo-Montero, D., Torriti, J., and Moreno-Munoz, A., Analysis and modeling of active occupancy of the residential sector in Spain: An indicator of residential electricity consumption. *Energy Policy*, 2013. 62(0): p. 742-751.
- [25] Santiago, I., Lopez-Rodriguez, M.A., Trillo-Montero, D., Torriti, J., and Moreno-Munoz, A., Activities related with electricity consumption in the Spanish residential sector: Variations between days of the week, Autonomous Communities and size of towns. *Energy and Buildings*, 2014. 79(0): p. 84-97.
- [26] Aerts, D., Minnen, J., Glorieux, I., Wouters, I., and Descamps, F., A method for the identification and modelling of realistic domestic occupancy sequences for building energy demand simulations and peer comparison. *Building and Environment*, 2014. 75: p. 67-78.
- [27] Chiou, Y.-S., Carley, K.M., Davidson, C.I., and Johnson, M.P., A high spatial resolution residential energy model based on American Time Use Survey data and the bootstrap sampling method. *Energy and Buildings*, 2011. 43(12): p. 3528-3538.
- [28] Richardson, I., Thomson, M., and Infield, D., A high-resolution domestic building occupancy model for energy demand simulations. *Energy & Buildings*, 2008. 40: p. 1560-1566.

- [29] Richardson, I., Thomson, M., Infield, D., and Clifford, C., Domestic electricity use: A high-resolution energy demand model. *Energy and Buildings*, 2010. 42(10): p. 1878-1887.
- [30] Widén, J., Lundh, M., Vassileva, I., Dahlquist, E., Ellegård, K., and Wäckelgård, E., Constructing load profiles for household electricity and hot water from time-use data--Modelling approach and validation. *Energy and Buildings*, 2009. 41(7): p. 753-768.
- [31] Grandjean, A., Adnot, J., and Binet, G., A review and an analysis of the residential electric load curve models. *Renewable and Sustainable Energy Reviews*, 2012. 16(9): p. 6539-6565.
- [32] Nordell, K., Kvinnors och mäns energianvändning (Rapport till Energimyndigheten). 2003, Kulturgeografiska institutionen, Handelshögskolan vid Göteborgs Universitet.
- [33] Löfström, E. and Palm, J., Visualising Household Energy Use in the Interest of Developing Sustainable Energy Systems. *Housing Studies*, 2008. 23(6): p. 935-940.
- [34] Blight, T.S. and Coley, D.A., Sensitivity analysis of the effect of occupant behaviour on the energy consumption of passive house dwellings. *Energy and Buildings*, 2013. 66(0): p. 183-192.
- [35] Corral-Verdugo, V.c., Bechtel, R.B., and Fraijo-Sing, B., Environmental beliefs and water conservation: An empirical study. *Journal of Environmental Psychology*, 2003. 23(3): p. 247-257.
- [36] Fan, L., Liu, G., Wang, F., Geissen, V., Ritsema, C.J., and Tong, Y., Water use patterns and conservation in households of Wei River Basin, China. *Resources, Conservation and Recycling*, 2013. 74(0): p. 45-53.
- [37] Krantz, H., Matter that matters. A study of household routines in a process of changing water and sanitation arrangements, in *Linköping Studies in Arts and Science no 316*. 2005, The Tema Institute, Linköping University: Linköping.
- [38] Zimmermann, J.P., End-use metering campaign in 400 households in Sweden - Assessment of the potential electricity savings. 2009, Energetech.
- [39] Eurostat, Guidelines on harmonised European Time Use surveys (2004 Edition). 2004.
- [40] Eurostat, Harmonised European time use surveys - 2008 guidelines. 2009.
- [41] Rydenstam, K. and Wadeskog, A., Evaluation of the European Time Use Pilot Survey. 1998, Statistics Sweden
- [42] Japac, L., Ahtiainen, A., Hörngren, J., Lindén, H., Lyberg, L., and Nilsson, P., Minska bortfallet. 1997, Statistics Sweden.
- [43] Sommer, R. and Sommer, B., A practical guide to behavioural research – Tools and Techniques (5th Edition). 2002, New York: Oxford University Press.
- [44] U.S. Census Bureau, American Time Use Survey User's Guide - Understanding ATUS 2003 to 2009. 2010.
- [45] U.S. Census Bureau. American Time Use Survey User's Guide. Understanding ATUS 2003 to 2012. 2013.
- [46] Mikael Molén, Department of Population and Welfare, Statistics Sweden [personal communication]. 2011.
- [47] Carlsson-Kanyama, A., Lindén, A.-L., and Eriksson, B., Hushållskunder på energimarknaden - Väderingar och beteenden. 2003, Forskningsgruppen för miljöstrategiska studier: Stockholm (FMS report 181).
- [48] Krippendorff, K., Content Analysis: An Introduction to Its Methodology (2nd ed.). 2004, Thousand Oaks, CA: SAGE.
- [49] Levin, P., Brukarindata bostäder. 2012, SVEBY (Standardisera och verifiera energiprestanda för byggnader): Stockholm.
- [50] Lindell, Å., Hantering av variationer i energiberäkningar för bostadshus. 2005, Avdelningen för installationsteknik, Institutionen för bygg- och miljöteknologi, Lunds tekniska högskola, Lunds universitet: Lund.
- [51] Sydkraft, Energiguiden för villor och småhus – För bättre säkerhet, ekonomi och komfort. 1998.
- [52] E.ON., Lilla energisparboken. 2007.
- [53] Sundsvall Energi. Hur länge räcker 1 kWh? 2012 [cited 2012 23 November]; Available from: <http://www.sundsvallenergi.se/default.aspx?id=1069>.
- [54] Schick, E., Jolivet-Tremblay, M., Dupont, C., Bertrand, P.E., and Tessier, J., Frequency-Volume Chart: The Minimum Number of Days Required to Obtain Reliable Results. *Neurourology and Urodynamics*, 2003. 22: p. 92-96.
- [55] Corti, L. Using diaries in social research. *Social Research Update* (issue 2) 1993 [cited 2014 2 April]; Available from: <http://sru.soc.surrey.ac.uk/SRU2.html>.
- [56] The Centre for Time Use Research. Centre for Time Use Research - information gateway. 2014; Available from: <http://www.timeuse.org/home>.

- [57] Cames, M. and Brohmann, B., Options and potentials of energy diaries - Energy diaries as a tool for identifying potential energy savings through behavioural changes, in ECEEE 2003 SUMMER STUDY. 2003.
- [58] Ellegård, K., Lockropen Ijuder: Kom hem, in Den gränslösa medborgaren. En antologi om en möjlig dialog, Schön, L., Amnå, E., and Ilshammar, L., Editors. 2002, Agora: Stockholm. p. 119-148.
- [59] Brasche, S. and Bischof, W., Daily time spent indoors in German homes – Baseline data for the assessment of indoor exposure of German occupants. *International Journal of Hygiene and Environmental Health*, 2005. 208(4): p. 247-253.
- [60] Leech, J.A., Nelson, W.C., Burnett, R.T., Aaron, S., and Raizenne, M.E., It's about time: A comparison of Canadian and American time-activity patterns. *Journal of Exposure Analysis and Environmental Epidemiology*, 2002. 12(6): p. 427-432.

Tables

Table 1 Categories of participating households

Household types		Housing area			Sum
		A	B	C	
I	Single persons, 26-64 years	1	0	0	1
II	Single persons, 65 years and above	0	0	0	0
III	Couples without children, 26-64 years	7	3	4	14
IV	Couples without children, 65 years and above	0	5 ^a	0	5
V	Families	14	11	12	37
Total number of households		22	19	16	57
Total number of persons		66	52	53	171

^a One couple has been categorised as Household Type IV, although they are not 65, because they are close to retirement age and because one person in the household is retired (disability pension) and the other person was unemployed at the time of measurement.

Table 2 Diary sheet used in the study (translated)

Time start	Time end	What am I doing?	Use of equipment, lighting or hot water - Household appliances - Lamps (including number of lamps) - Other electronic equipment - Regulating temperatures (radiators) - Hot water usage	Where? - which room in the house - garage - storage - garden	Comments

Table 3 The characteristics of cluster solutions with standardised and non-standardised of diary data values

Cluster solutions		No. of households	Average no. of persons	Household types (no. of households)					Housing areas (no. of households)			Average indoor temperature (°C)
				I	II	III	IV	V	A	B	C	
Standardised	Cluster 1 _s	18	2.2	1	0	7	3	7	7	6	5	20.7
	Cluster 2 _s	29	3.5	0	0	3	2	24	11	12	6	20.7
	Cluster 3 _s	8	3.3	0	0	2	0	6	2	1	5	21.0
	SUM	55	-	1	0	12	5	37	20	19	16	-
Non-standardised	Cluster 1 _n	24	2.1	1	0	12	5	6	8	10	6	20.5
	Cluster 2 _n	23	3.5	0	0	0	0	23	10	7	6	20.8
	Cluster 3 _n	8	4.5	0	0	0	0	8	2	2	4	21.1
	SUM	55	-	1	0	12	5	37	20	19	16	-

Table 4 The characteristics of cluster solution with standardised values of diary data and typical power values

Cluster solutions		No. of house-holds	Average no. of persons	Household types (no. of households)					Housing areas (no. of households)			Average indoor temperature (°C)
				I	II	III	IV	V	A	B	C	
Standardized	Cluster 1 _{p,s}	30	2.6	1	0	10	4	15	14	9	7	20.6
	Cluster 2 _{p,s}	20	3.6	0	0	2	1	17	6	10	4	20.9
	Cluster 3 _{p,s}	7	3.3	0	0	2	0	5	2	0	5	21.1
	SUM	57	-	1	0	14	5	37	22	19	16	-

Table 5 Average time (mean) for a number of activities, expressed as minutes or number of times (frequency) during a day¹. The figures in brackets state the number of households performing the activity. Presentation for Thursday, Friday and Saturday.

Activity (variable)	Average time spent on a number of activities (minutes per day)		
	Note, for a number of activities, the frequency is stated (times per day). In brackets: no. of households performing the activity		
	Thursday	Friday	Saturday
Electronics			
1. TV	326 (55)	287 (53)	375 (53)
2. Computer	162 (37)	140 (32)	205 (31)
3. Stereo/Radio	115 (24)	98 (21)	72 (26)
4. Electric clocks	51 (2)	51 (2)	51 (2)
5. DVD/VHC	15 (8)	30 (12)	37 (13)
6. Video games	14 (4)	10 (2)	12 (3)
7. Engine preheaters	17 (7)	13 (8)	5 (3)
8. Car heater	11 (6)	6 (6)	6 (2)
9. Vacuum cleaner	8 (17)	3 (12)	8 (18)
10. Printer (times per day)	0 (1)	0 (2)	0 (1)
Cooking/Kitchen			
11. Kitchen fan and other fans	66 (22)	60 (19)	71 (29)
12. Stove	22 (36)	22 (37)	45 (48)
13. Coffee machine	21 (31)	28 (32)	30 (42)
14. Oven	14 (13)	17 (13)	20 (16)
15. Microwave	4 (46)	5 (37)	4 (37)
16. Hand wash (dishes)	5 (24)	3 (16)	7 (26)
17. Toaster	0 (2)	0 (3)	3 (7)
18. Electric mixer	0 (3)	0 (0)	0 (0)
19. Electric kettle (times per day)	0.7 (21)	0.6 (19)	0.5 (16)
20. Dish-washer (times per day)	0.4 (21)	0.3 (17)	0.4 (21)
21. Food processor (times per day)	0 (1)	0 (1)	0.1 (3)
Personal hygiene			
22. Shower	9 (45)	8 (39)	12 (41)
23. Hairdryers	1 (15)	2 (21)	1 (12)
24. Curling tongs or straighteners	1 (5)	0 (4)	1 (3)
25. Bathing (times per day)	0 (3)	0 (3)	0 (3)
Comfort			
26. Towel dryer	134 (8)	137 (8)	142 (8)
27. Airing	101 (20)	81 (17)	120 (22)
28. Floor heating (comfort)	77 (4)	76 (3)	76 (3)
Clothes care			

¹ Note that if multiple devices are used at the same time in a household, these are still entered for the same variable, which represents a certain device/activity and a certain hour of the day. This means that the number of minutes can be summed up to more than 60 minutes for a variable. For this reason, the number of minutes stated in the table can seem unreasonable if one forgets that they represent all devices that are used for a certain activity of a whole household.

29. Tumble-dryer	16 (10)	14 (9)	21 (14)
30. Iron	2 (5)	3 (7)	9 (10)
31. Drying cupboard	16 (2)	14 (0)	21 (1)
32. Hand washing	0 (2)	0 (2)	0 (1)
33. Sewing machine	1 (1)	0 (0)	1 (2)
34. Washing machine (times per day)	0.5 (22)	0.6 (24)	0.8 (30)
Others ²			
35. Very low power (<100W)	236 (16)	192 (13)	170 (17)
36. Low power (100-500W)	77 (7)	79 (11)	62 (9)
37. High power (500-1000W)	0 (1)	0 (2)	0 (1)
38. Very high power (>1000W)	77 (5)	79 (5)	86 (9)
39. Changes (times per day)	0.3 (9)	0.2 (6)	0.2 (8)
Further variables			
40. Presence	-	-	-
41. No. of persons	-	-	-
42. Water use (litre/household, day)	-	-	-
43. Water use (litre/person, day)	-	-	-
44. Indoor temperature (°C)	-	-	-

Table 6 ANOVA results showing significant differences (p-value $\leq$ 0.05) between the different activities performed by households in suggested clusters - shown for three different cluster analyses. Average values for each cluster are also shown.

Activity (variable)	Cluster analysis of diary data. ANOVA results, variables (activities) with p-value ≤ 0.05.							Cluster analysis of diary data and typical power values, p. ANOVA results, variables (activities) with p-value ≤ 0.05. Standardised values, s				
	Standardised values, s				Non-standardised values, n							
	Significance level	Cluster 1 _s	Cluster 2 _s	Cluster 3 _s	Significance level	Cluster 1 _n	Cluster 2 _n	Cluster 3 _n	Significance level	Cluster 1 _{p,s}	Cluster 2 _{p,s}	Cluster 3 _{p,s}
1. TV (minutes per day)					0.002	992	1409	1812	0.054	-0.25	0.43	-0.17
2. Computer (minutes per day)					0.007	325	811	1306				
4. Electric clocks (minutes per day)	0.001	-0.19	-0.19	1.16								
7. Engine preheaters (minutes per day)	0.004	-0.12	-0.20	1.07					0.000	-0.20	-0.27	1.61
8. Car heater (minutes per day)									0.001	-0.21	-0.14	1.30
11. Kitchen fan and other fans (minutes per day)	0.036	-0.11	-0.17	0.84					0.009	-0.06	-0.28	1.03
12. Stove (minutes per day)	0.019	-0.48	0.35	-0.05								
14. Oven (minutes per day)	0.004	-0.50	0.43	-0.33								
16. Hand wash (dishes) (minutes per day)	0.019	-0.49	0.14	0.59	0.020	15.0	20.8	49.0				

² Others include four variables that are based on the possible power usage of the activities in question. There is also a variable called Changes that include changes that have been performed during the diary period that might have an influence on the energy use, i.e. changing settings for boiler/water heater, heat pump, power cut, blown fuse.

19. Electric kettle (times per day)					0.006	2.4	1.6	6.0				
20. Dish-washer (times per day)					0.006	1.2	1.9	4.3				
21. Food processor (times per day)									0.016	-0.34	0.47	0.12
22. Shower (minutes per day)					0.029	31.0	47.9	38.5				
24. Curling tongs or straighteners (minutes per day)	0.000	-0.32	-0.14	1.32								
27. Airing (minutes per day)	0.011	-0.15	-0.21	0.91					0.000	-0.09	-0.35	1.39
28. Floor heating (comfort) (minutes per day)									0.052	-0.23	0.43	-0.23
29. Tumble-drier (minutes per day)									0.003	-0.38	0.57	-0.00
30. Iron (minutes per day)	0.039	-0.33	0.34	-0.37								
33. Sewing machine (minutes per day)	0.024	-0.19	-0.12	0.90					0.009	-0.12	-0.19	1.05
34. Washing machine (times per day)	0.004	-0.50	0.41	-0.33								
36. Low power (100-500W) (minutes per day)									0.035	-0.26	0.46	-0.18
37. High power (500-1000W) (minutes per day)	0.005	-0.24	-0.12	1.05					0.000	-0.20	-0.24	1.52
38. Very high power (>1000W) (minutes per day)	0.000	-0.22	-0.24	1.42					0.000	-0.23	-0.24	1.67
39. Changes (times per day)	0.001	0.72	-0.32	-0.43								
40. Presence (minutes per day)	0.000	-0.84	0.49	0.32	0.000	7805	12859	19321	0.003	-0.42	0.50	0.35
41. No. of persons	0.000	-0.81	0.50	0.24	0.000	2.1	3.5	4.5	0.002	-0.42	0.53	0.28
42. Water usage (litre/household, day)	0.000	-0.83	0.47	0.17	0.000	262	372	431	0.039	-0.33	0.33	0.39