Swedish homes – towards a delight future?

PhD Helena Krantz
Dept. of Technology and Social Change
Linköping University
Sweden
helkr@tema.liu.se

Anette Persson
Swedish Energy Agency
Sweden
anette.persson@energimyndigheten.se

Peter Bennich
Swedish Energy Agency
Sweden
peter.bennich@energimyndigheten.se

Ass Prof. Mats Bladh
Dept. of Technology and Social Change
Linköping University
Sweden
matbl@tema.liu.se

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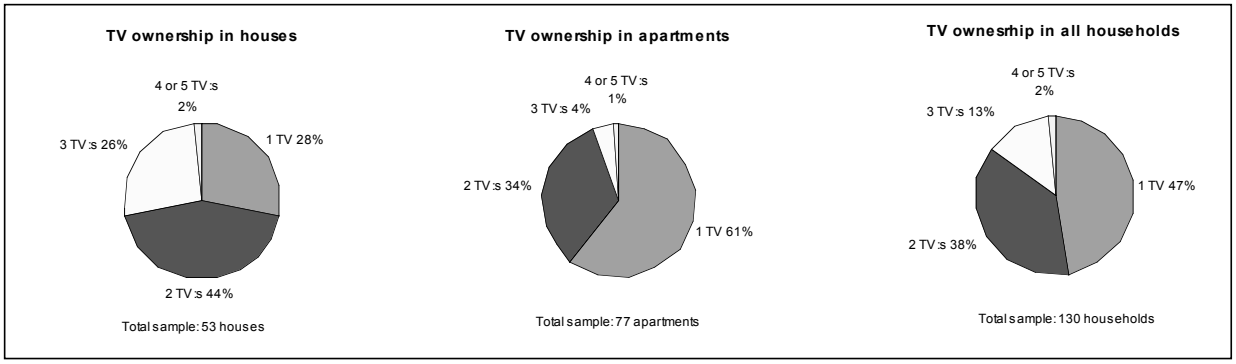
Abstract
The Swedish Energy Agency is conducting a thorough investigation of household's electricity consumption and the ownership of electric appliances. Detailed measurements and inventories are being performed in 400 households. Some preliminary results of the inventories are presented in the first part of this paper. In connection with the investigation, two related research projects are being performed, one of which is studying the use of electric lighting. Based on in-depth interviews with households taking part in the investigation, electric lighting usage patterns in different types of households are analyzed. The methodology and preliminary results from this in-depth study on lighting are presented in the second part of the paper.

Introduction
A detailed monitoring program to investigate household electricity use in Sweden started in 2005 and will continue until the beginning of 2008. Measurements of household electricity and inventories of electric appliances are being performed in 200 houses and 200 apartments. The selection of households has been done in cooperation with the statistics agency in Sweden, "Statistics Sweden", where households representing different types of families in combination with the type of house or apartment in terms of age and location (big town, small town, countryside), have been chosen.

Preliminary results – inventory of electric appliances
The following graphs are based on a sample of 130 households (53 houses and 77 apartments). When the monitoring program is finished the total sample will be 400 households.

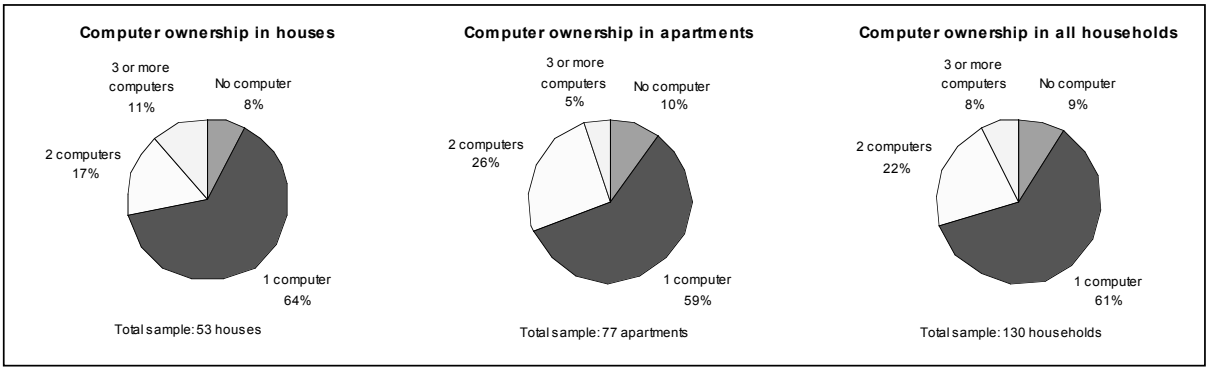
Half of Swedish households have two or more televisions



Graph 1: TV ownership in Swedish households

In the total sample of 130 households there is one household (apartment) that has no television. The maximum number of televisions encountered in the sample is five (also in an apartment).

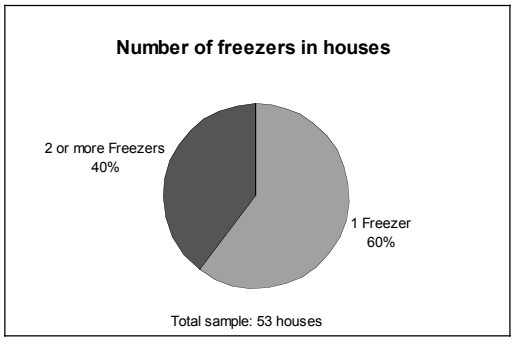
Nearly 30 % of Swedish households have two or more computer sites



Graph 2: Computer ownership in Swedish households

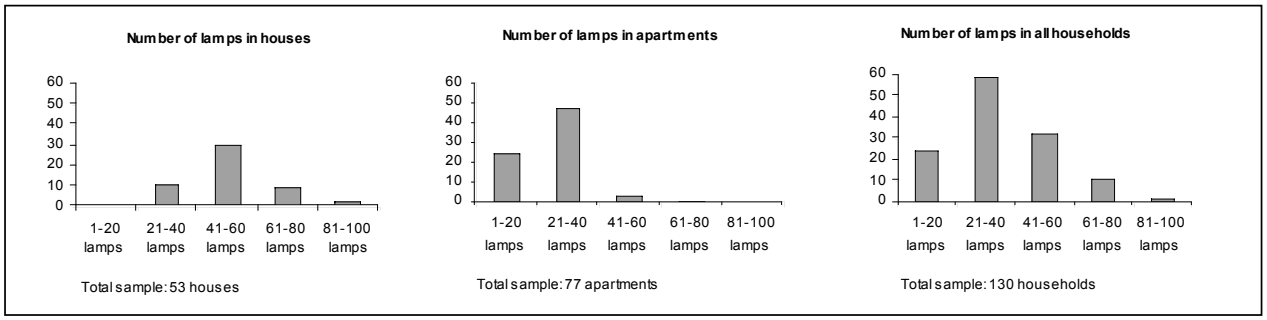
The maximum number of computer sites encountered in one household is six (in an apartment).

40 % of Swedish houses have two or more freezers

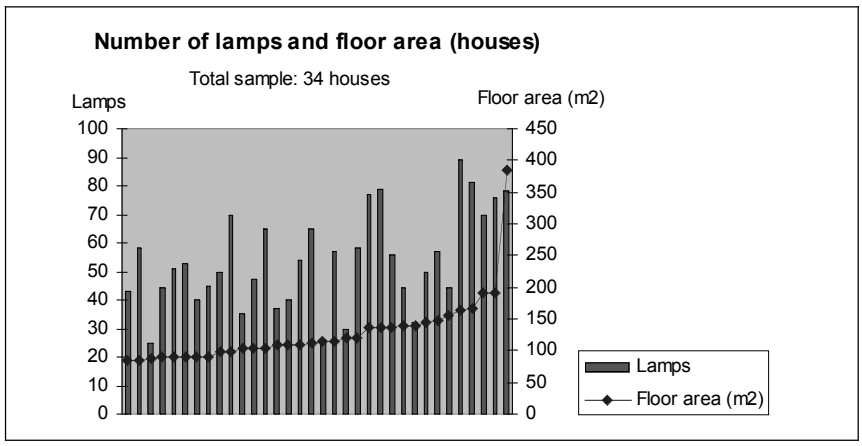


Graph 3: Number of freezers in houses

The number of lamps varies a lot in different households



Graph 4: Number of lamps in Swedish households



Graph 5: Number of lamps and floor area

When the number of lamps is related to the floor area, there is some correlation but the variations are big.

Focus on lamp use

In Sweden lighting constitute on average about 20 % of a household's total electricity use[1] (IVA, 2002). We know little about what influences this in international comparison high figure. It may reflect a cultural preference towards the 'warm' light provided by incandescent lamps, to the disadvantage of the more energy-efficient but 'colder' light provided by fluorescent and compact fluorescent lamps (CFL). There seems to be a reverse relationship between light quality (warm and cold) and climate (Starby, 2003), which is confirmed in a comparative study between lighting use and preferences in Norway and Japan respectively (Wilhite *et al*, 1996). In both countries, the illumination of the home was part of an 'appropriate' interior but the definition of what that involved diverged. In Norway 'cosiness' was emphasised, while the Japanese stressed functionality. In concrete terms; the Norwegian households were extremely lighting intensive compared to the Japanese. The Norwegian living room had on average 9,6 lamps, mostly incandescent and primarily fitted in floor and table lamps to create a cosy feeling. Their Japanese counterparts, on the other hand, had on average 2,5 lamps, mostly fluorescent and primarily fitted in ceiling lamps to create a light suited for seeing properly. It is likely that the results for Norway also apply in Sweden to some extent.

Lighting is also comparatively strongly dependent on behaviour – habits, needs and occupancy patterns in the home (Bladh, 2005). Contrary to many other electrical appliances, lamps are highly dependent on user intervention in both switching on and off[2]. Have the historically low electricity prices made Swedes into negligent lighting consumers, leaving lights on in rooms that are not used and even when leaving the house? Consequently, there is *potentially* much electricity to save in Swedish households by a change of lamp technology from incandescent to CFL and by changing lighting behaviour. However, the question is: what do the households' lighting habits look like before we intervene and what are the main factors that motivate the current patterns of use? Moreover: do households find it appropriate or acceptable to switch off the lights in rooms which are not in use and before leaving the house? Do households want CFLs in all lamps?

AIM OF STUDY

The aim of this study was to assess the electrical energy savings potential for lighting in households. The aim was made operational by the following research questions:

- What are the household habits with regard to lighting and how are these habits motivated?
- What kind of lamp technologies have households previously experienced, what kind of lamps are presently in use and what do households think about new technologies and innovations such as CFL (low-energy lamps) and motion sensors?
- Do households consider it possible and relevant to economise on lighting as an energy-saving measure?

Questions of purchase and disposal are also examined, as are the possibilities to translate the energy consciousness that the watt label on lamps provides on to other electrical appliances.

The spread in electrical energy consumption for lighting in households is probably large. We aim to test two hypotheses likely to influence this spread.

Firstly, *consumption of electricity for lighting is related to age and older people use less electricity for lighting in both absolute and relative terms*. Previous studies have in a way already confirmed this hypothesis. What is unclear, however, is the age groups to which this applies and how the economic behaviour has evolved and been maintained over the years. Does the thrifty behaviour arise at older age irrespective of background, or have younger generations adopted an increased stockpile of lamps alongside the general increase of electrical appliances in the homes so that we get some sort of age group pattern among households when it comes to electricity consumption? This study seeks to find out how thrifty behaviours evolve and are maintained, which is important since here we have an existing energy-efficient behaviour that can be supported, maintained or even perhaps enhanced.

Secondly, *consumption of electricity for lighting is related to household size and per capita use is less in larger households.*

1. Refers to electricity use for lighting, white goods and electrical appliances. Heating and hot water is not included.

2. Lamps could be connected to timers or motion sensors, which thus constitute exceptions.

Table 1 Household selection criteria matrix and real counterparts

Size \ Age	20-35	36-64	65+
1	**Single young:** Woman, 32 y. Rented flat, middle-sized town.	**Single middle:** Man, 64 y. Rented flat, large town (city-centre).	**Single old:** Woman, 69 y. Rented flat, large town (city-centre).
2	**Couple young:** Couple, 30 y. Tenant-owner flat, large town (city-centre).	**Couple middle:** Couple, 42 y. Rented flat, large town (city centre).	**Couple old:** Couple 75 and 78 y. Private house, middle-sized town.
≥3	**Family young:** Couple, 33 and 34 y with two children. Private house, small town.	**Family middle 1:** Couple, 36 y with one child. Tenant-owner flat, large town (city-centre). **Family middle 2:** Couple, 41 and 42 with three children. Private house, large town (suburb).	*Category not found relevant*

The share of one-person households in Sweden has increased continuously after 1945 (a similar trend is evident in most developed countries around the world), and today they constitute 47 % of all households. This affects electricity use by reducing the co-usage of electrical appliances. For instance, irrespective of how many people that live in an apartment, the hall needs a certain amount of lighting and the amount is not likely to increase proportionally to the number of residents. However, larger households normally live in larger dwellings and to be a co-habitee can affect one's use of lighting. A household with many members is also potentially using their dwelling more hours of the day, increasing lighting needs accordingly. One-person households may also compensate the co-usage through buying fewer lamps and by switching off lamps in empty rooms.

By focusing on these two hypotheses we can pay attention to issues of fundamental importance for increased energy-efficiency of lighting use, namely by understanding how energy economising behaviour develops and persists and how such behaviour can be supported, and the relative importance of external conditions versus habits in relation to electricity consumption.

METHOD

The study is based on in-depth interviews with households, which were selected with respect to the hypotheses to be tested. Concerning household size we have focused on the most common sizes; one-person households, two-person households (couples without children or with children who have left home) and households with three or more persons (couples with children). With respect to age we have found the following cohorts appropriate: 20-35 years (young adults), 36-64 years (middle aged) and 65 years and above (older). Taken together this gives three age groups and three household types according to the matrix below, including the actual counterparts (Table 1).

Older households (65+) consisting of more than two persons is very uncommon in Sweden and therefore this category is not covered in this study. Two households with different terms of occupancy; private house and tenant-owner flat respectively, have been selected in the category adults in the age of 36-64 with three or more persons. This demonstrates the importance of dwelling size and shared lighting.

Preliminary results – focus on lamp use

The study is still in progress. All qualitative material has been collected but measurement data is still being analysed. Therefore the results presented here are preliminary and should be used with caution.

An early analysis on a small sample of the measured households in SEA's study showed that incandescent lights still represent a large part (60 %) of the total number of lamps in Swedish homes, while the use of CFLs is still low (about 10 %). The consumption of electricity for lighting initially measured is the same or even higher compared to figures from the mid 1990s. Lighting makes up over 20 % of the total electricity usage in an average household, excluding electricity for heating (Bennich and Persson, 2006). From these figures it seems that there is a substantial potential to lower total electricity use by altered lighting behaviour and/or by changing incandescent lights for CFLs. But what possibilities and restrictions for such a development are found in the households?

The size of the dwelling is important both in terms of the total number of lamps and installed wattage. Households in the larger detached houses have considerably more lamps and higher total wattage installed. But taking the number of rooms into account, the differences between dwelling sizes is diminished. Lamp possession thus seems to be related to the number of rooms to be illuminated, not dwelling area (m^2) or terms of occupancy. However, number of lamps is probably not a very good indicator of lighting electricity use in a household. For instance, older people may remain in their large flat or private house after the children have left home and even after the wife or husband has passed away. They probably have many lamps, but that is not as interesting or important as how they are used. A large number of installed lamps may be offset by not using parts of the dwelling regularly, switching off lamps in empty rooms or by having some lamps turned on only for special occasions, such as when having guests.

Age may be important. Wattage per lamp increases with resident age within each household size group. If there is such a relationship, it may be partly explained by the higher prevalence of CFLs on the market when younger persons were developing their purchasing habits. However, the share of CFL is generally still low, even in young households. The largest CFL share was found in Family middle 1 (40 %) and Single young (25 %). Three households have no CFLs (but other fluorescent

lighting has not been included in these cases). Objections to CFLs were about the quality of light (colder and weaker than incandescent), the low light output when initially turned on, their appearance and that fact that CFL-lamps are expensive to buy. However, respondents who have CFLs today are mainly positive towards them and those with no CFL are curious about them and can be labelled as potential buyers. Thus it seems that what is lacking is something that triggers households to select CFL before incandescent at the moment of purchase.

The perceived colder light of CFLs may be a constraint towards their increased adoption since 'cosiness' was considered very important by several of the respondents. However, the experience of light quality is also dependent on the type of lamp shade or fitting. An open shade, where it is possible to see the bulb and which does not screen off the light, is more sensitive in this respect than a lamp shade that covers the entire bulb and provides a 'filter' and diffuser that makes the light appear as softer and warmer. Creating a cosy atmosphere at home is important, not only with electric light, but also with candles. Candles did not replace electric light in most cases, but were complementary. A disabled man and a family with a child saw considerable risk for causing fire when candles were used, and thus avoided them.

Another important aspect, possibly impacting on both lighting behaviour and adoption of CFLs, is the respondents' vague notions about total electricity consumption, or total costs for electricity, and lighting's share of total electricity consumption. Some guessed that lighting makes up for a large part of the total bill, but within the frames of a low total consumption, others that it is a small part. Wattage given on lamps was associated with light, not with power or energy use, without exception.

To save electricity or not is an important question. The reason mentioned for saving electricity was with reference to the environment, but this was qualified by stating that savings should be reasonable. There are limits for what you can do by way of turning off lights. You can turn off lights when leaving a room for a longer period, but lighting for cosiness may be left on. The two households with children living in larger detached houses also kept lights on in empty rooms since some of the children were afraid of the dark and were too small to reach the switch by themselves. Only one household, the old couple, thought switching off lamps could be done extensively.

Timers and motion sensors were in use in several of the homes we visited, which means that they are considered useful. All motion sensors were used for lamps outdoors or in cellar spaces, such as garages and common laundry rooms. The respondents were a bit more hesitant towards using motion sensors inside the flat or house, since lights could go off when nobody is moving for a short period or all lights in a room could be turned on when somebody enters, which is unnecessary. However, for rooms visited only shorter periods at a time (e.g. bathroom, hall) a potential interest in motion sensors was expressed.

The most important aspect when new lamps are bought is that they are functional. It is also important that they look nice and fit the rest of the interior, an aspect especially emphasised by the younger households. The type of light bulb is subordinate; only one household (young couple) mentioned the importance of fittings which require special light bulbs which may be difficult to obtain. Light bulbs are largely purchased in large-pack in discount stores, hence the price seems to matter somewhat. When incandescent lights are changed, the disused non-functioning bulb is usually thrown into the garbage bin, while fluorescent lights, without exception, are put in special containers (to limit mercury content entering the waste stream). No one really knows what to do with used CFLs, resulting in disposal of CFLs in household garbage. The confusion may be related to CFLs being crossbreed of incandescent lights (exterior design) and fluorescent lamps (interior technology), and only those who know the fluorescent origin have realised that CFLs should be handled in the same way as fluorescent lights.

The results presented here are just examples of aspects covered by the total study, and they will be elaborated upon in much more detail in the forthcoming report (end of 2007). Through knowledge of actual electricity consumption, attitudes and everyday activities, we will be able to discern measures for increased lighting efficiency. Should we advise people to switch off the light systematically as soon as it is no longer required? Should people have bad conscience for their built-in halogen spot lights? At this stage, it looks as if we will put emphasis on those measures that reduce the household demand for kilowatt and kilowatt-hours without reducing the quality of light – and quality of life. Much can be done in this area and we believe it will be an important contribution to the overall energy system changeover.

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Acknowledgements

Data from the Swedish end-use monitoring campaign that will continue until December 2007. See www.stem.se for more information.