

# Energy Use in Single-Family Houses in a Cold Climate

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## Introduction

The study deals with *everyday* energy use in rather new houses. The theoretical framework is provided by social sciences. The study falls into two parts. (1) The first part provides background information by examining the general trend in residential energy consumption between 1982 and 1990 in 300 single-family houses, with special reference to its connection with the stage of the family-life cycle. (2) The main body of the study provides an in-depth, largely qualitative analysis of the connection between differences in life-style and energy use in fifty families with two teen-age children.

The qualitative part *describes how the present level of energy consumption and the present pattern of behaviour related to energy use have evolved in different types of family*. Special attention is paid to determining the residents' own view of energy-related behaviour. Therefore, rather unstructured thematic interviews have been used. The aim is to gain a better understanding of how families make their energy-related decisions. Another, exploratory aim of the study is *to find new hypotheses* for further research. The results will, however, lend themselves to immediate application in all efforts to promote energy saving by means of information.

## Methodology

The houses studied date from the period 1975-82, so they have been built using new building technologies and renovations do not affect data on changes in consumption. The randomly selected houses were located in the area around Helsinki in southern Finland and were heated by electricity or district heat. Each family owned the house concerned. The fifty families interviewed were two-parent families with two children aged 10-24 years. Before the interview the parents filled out a questionnaire concerning the family's present behaviour and the technical factors affecting the family's energy use. In the thematic interviews, changes in behaviour and differences in the preferences of family members were discussed. The interviews were taped, with both husband and wife present usually. The indoor temperature was measured in connection with the interview.

The data on both energy and water consumption were obtained from the utilities. The estimated share of space-heating has been adjusted for weather. Possible supplementary heating by wood-burning fireplaces is not included in the consumption figures.

## Results

### The General Trend in Residential Energy Consumption and its Connection with the Family Stage

The study showed that residential energy consumption increased in the late 1980s (Table 1). This was a period when energy prices were down in real terms and the families covered had more space for economic manoeuvring. These factors cannot be separated from each other in this study.

*A major finding* was that there were *great differences in the change in the level of residential energy consumption between families in the same family stage, which clearly points to differences in life-style* (Table 2). The main body of the study provides an in-depth analysis of these differences with reference to families of four with teen-age children.

### Residential Energy Consumption and its Correlates in Families of Four

Differences in the level of residential energy consumption had increased between families of four with teen-age children. The increase in the level of consumption was greatest for houses with a high level of consumption ( $r = .77$ ,  $p < 0.001$ ), as can be seen from Figure 1. The figure also shows that the correlation between the size of the house and the level of consumption was not high because specific consumption (kWh per square meter of useful floor area) also varied considerably.

The level of family income correlated with total energy consumption ( $r = .34$ ,  $p = .02$ ) mainly because of the larger houses of families with higher incomes ( $r = .35$ ,  $p = .02$ ).

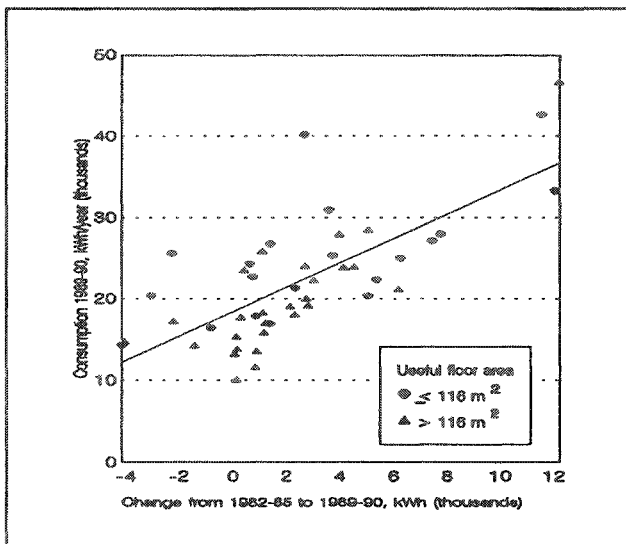
*Table 1. Average Residential Energy Consumption by Components and Water Consumption Per Person in 1982-85 and 1989-90 (N=292)*

<u>Period</u>	<u>Operation of Household Appliances<sup>(1)</sup></u> kWh Per Year	<u>Water Heating<sup>(2)</sup></u>	<u>Space Heating<sup>(3)</sup></u>	<u>Total Energy Consumption</u>	<u>Water Consumption Per Person</u> Litres Per Day
1982-85	5,570	3,550	11,250	20,370	117
1989-90	6,370	3,750	12,590	22,710	136
Change	800	200	1,340	2,340	19
%	+14%	+6%	+12%	+11%	+16%

- (1) Based on electricity consumption of families using district heating.  
 (2) Estimated on the basis of family's water consumption.  
 (3) The residue.

*Table 2. Change in Consumption (%) from 1982-85 to 1989-90 According to Family Stage: Mean and Standard Deviation*

<u>Stage in the Family Life Cycle</u>	<u>Mean</u>	<u>Standard Deviation</u>	<u>(N)</u>
Couples with two children throughout 82-90	+15	19	(84)
Couples with children only in 82-85	+12	12	(18)
Couples without children when moving into the house	+6	16	(21)



*Figure 1. Connection Between the Level and the Change in the Level of Consumption in Families of Four (N=50)*

The correlation between family income and the change in energy consumption was less strong ( $r=.24$   $p=.13$ ). The positive correlation between increase in consumption and the wife's status of upper-level white-collar worker ( $r=.50$   $p=.0005$ ) and the negative correlation between increase in consumption and the wife's status of blue-collar worker ( $r=-.29$   $p=.06$ ) were the strongest.

Regular use of wood-burning, heat-storing fireplaces to produce supplementary heating was the factor with the most marked effect on the level of specific consumption ( $r=-.52$   $p=.0002$ ). To some extent, use of wood correlated positively to the wife's status of blue-collar worker status ( $r=.19$   $p=.19$ ) and negatively with the wife's status of lower-level white-collar worker ( $r=-.21$   $p=.15$ ). Water consumption, too, correlated strongly with specific consumption ( $r=.47$   $p=.001$ ) and with the change in energy consumption ( $r=.37$   $p=.013$ ). Of the factors of water consumption, frequency of showers correlated with the regular use of wood ( $r=-.41$   $p=.004$ ).

There were differences in the indoor temperature in sub-zero (centigrade) weather. The mean of the temperature measurements was 22.5°C (72.5°F) and the standard deviation 1.3°C (2.5°F). The residents underestimated the temperature by 1°C (=1.8°F) on average. The thermometers often gave unreliable readings, and the thermostats were often inaccurate or their operation was not properly understood by all family members.

From earlier energy saving information, the families had adopted the view that the energy consumed for lighting and for operating appliances is of use in heating, resulting in the misconception that it was unnecessary to pay any attention to these things.

The adequacy of ventilation during winter was difficult to judge, because no technical metering was done. There were families leaving a window ajar in mild weather without turning off the thermostat. On the other hand, ventilation could also be insufficient in the new tightly insulated houses.

The personal habits of showering and of changing and washing clothes differed both between families and between family members. The habits of teen-agers were often the object of mild parental criticism, but an effort was made to avoid open conflict.

Few of the families covered kept track of their energy or water bills. Most of them were unaware of any changes in their consumption and had no clear idea of how the level of their consumption compared with that of the other families' consumption. Not even the few families that paid more attention to energy consumption made any adjustments for weather. So they could not very well become aware of the changes in their behaviour.

The effect of energy price and tariff composition could be seen in the differences between families heating by electricity and those using district heating. The two groups were of similar socio-economic backgrounds. Energy saving was economically less profitable to families with district heating because district heat was cheaper than electricity and had a fixed rate high in proportion to variable energy costs. Both specific consumption and the increase in consumption were higher among families heating with district heat. Their average indoor temperature was 1°C higher and they burned less wood than families heating by electricity. There was, however, variation in both groups.

## Conclusions

Although the analysis still continues at the time of writing, the following qualitative conclusions can already be drawn.

Very few of the families studied saved energy consciously. Thus the observed differences in energy-related behaviour between families reflect life-style differences in a situation where very little attention is paid to energy.

Many of the observed differences in the behaviour pattern were not connected with any clear socially determined welfare needs or social norms. Rather, a number of factors linked with high energy consumption were to do with personal habits whose appropriateness had not been questioned. Habits linked with low consumption often related to parents hailing from the country.

The families covered showed hardly any awareness of a need to change their behaviour. They considered their behaviour as average, not wasteful. A very important conclusion is therefore that families need better feedback information about their consumption in order to become aware of its changes and of its level relative to other families. The extent to which this will influence their behaviour will depend on many factors that have not been examined in this study. The residents' view of the connection between energy use and environmental problems, and of the overall need to save energy, will play a key roll here. Of great importance will also be their view of energy saving efforts in the other sectors of society and of the significance of their own efforts. To forecast any trends in energy consumption is therefore difficult on the basis of the results.

The analysis of the data continues. The aim is to examine areas where the residents waste--or seem to waste--energy and to point out areas where their energy awareness should be improved. Another aim is to examine how the everyday role of various energy consuming factors differs between families. This will benefit all efforts to promote energy saving by means of information.