The Effect of Feedback and Focused Advice on Household Energy Consumption

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Synopsis

During 17-21 months, feedback or mere monitoring decreased heat, electricity and water consumption in 105 single-family houses. Focused advice had no further influence.

Abstract

The aim was to monitor the effect of focused advice on householders' behaviour with regard to energy consumption. 105 district-heated single-family houses were divided at random into four groups. The households read and sent in their heat, electricity and water consumption figures during a 21 month period. Feedback on their consumption was sent monthly to three of the groups during 17 months, the fourth acted as a control group. Based on an interview and enquiries about the respondents' habits and their willingness to change, focused advisory materials were prepared and delivered, after 12 months monitoring, to two of the groups, either on video or as literature.

Heating energy consumption decreased by average of 5 %, when the households began to read their meters. After receiving feedback on consumption, households reduced their energy consumption for space heating 3-9 % compared with the same months of the previous year. Electricity consumption also decreased after the feedback, by 17-21 %. After feedback, focused advice had no further influence.

The more new habits were adopted, the more the electricity consumption decreased. The most common energy-saving measures applied were turning off the lights in empty rooms, reducing water consumption relating to personal hygiene, and lowering the room temperature.

Most of Finnish district heating customers have had feedback on their heat consumption since the middle of the 1980´s. Reports have been very variable in different energy and district heating companies. The Finnish District Heating Association has improved the feedback reports and developed model reports.

1. Introduction

The aim of the project was to monitor the effect of feedback and focused advice on householders' behaviour (habits connected to housework and the use of household appliances, adjusting or regulating of heating, ventilation etc.) and on heating energy, electricity and water consumption.

2. Methodology

2.1 Survey

2.1.1 Households

All households in district heated single-family houses in five areas of Southern Finland were asked whether they would be willing to participate in the monitoring. These totalled about 1 500 households, of which about 480 households stated their willingness to take part and gave some background information of the building and the household in response to a questionnaire. Of the 480 households 123 were selected according to certain criteria, connected mainly to the properties of their building.

The selected families were interviewed in October-November 1993. An inquiry was sent concerning the household management, such as cooking and food storage, laundry and dish washing, washing habits, lighting, heating, ventilating and etc. i.e. all the customs and habits influencing the family's energy and water consumption.

The researchers visited all the households, checked and collected the inquiries and interviewed the families about their attitudes and willingness to save energy. The families named the areas in which they could save energy and the kind of information they wanted with respect to energy saving. Energy meters were installed in 40 appliances in different households with special attention being paid to old fridges and freezers.

2.1.2. Experimental Gr oups

In order to compare the effects of various information techniques, the households were divided at random into four groups sharing similar characteristics regarding family size, attitude categories and household appliances being measured for energy consumption. These groups were influenced by different treatments (Figure 2-1).

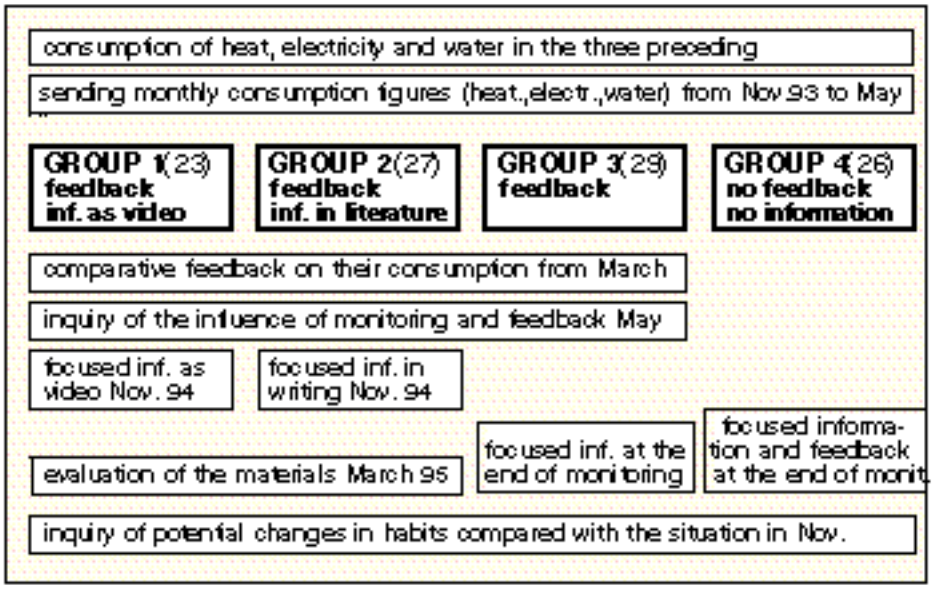

Figure 2-1. The preconditions of households, the household groups and their treatments.

A blind control group for heating was formed consisting of 650 district-heated single-family houses. For household electricity and water, the rest of permitting the data collection on their households were used as a blind control group.

All households sent in a monthly form with their readings of heat-, electricity -and water consumption from

December 1993 to August 1995. During the monitoring 18 households dropped out, mostly because they moved or the size of the family changed.

2.1.3 Different Treatments of the Households

Feedback on consumption
83 % of the households wanted comparison between the consumption of their own house and similar houses in Finland as feedback material. 69 % of households also wanted to see comparative figures for participants in this study. They also wanted to have energy consumption translated into the costs they had to pay.

The feedback material was made according to the wishes of the households. Since March 1994 groups 1-3 received monthly comparative feedback by post in graphic form about their energy costs and heat, electricity and water consumption in relation to comparable households in this study and also in terms of their own consumption in preceding years.

Focused advisory work
Focused information materials were prepared, including details of the different brands of heating and ventilation systems and adjustment devices available to households, and advice about different ways of doing housework and producing household services. Advisory materials were prepared according to the wishes of the households, keeping in mind questions which had already been asked by the households. The materials were prepared in the form of a video and literature with the same content. Each household in groups 1 and 2 received its own material. The attention of each household was drawn to the relevant sections of the materials relating to households' willingness to save energy in specific areas.

Inquiries
In May 1994 an inquiry was sent to the households asking for their opinions about the feedback material and about the influence of monitoring and feedback. In May 1995 the households were asked about any changes in their habits in using space heating adjustments, ventilation, etc. and their habits concerning household electricity and water during the monitoring period compared with the situation in November 1993.

2.2 Data Processing

2.2.1 Preparation of the Base Data

Changes in the consumption of energy (heating and household electricity) and water in each household were monitored from December 1993 to August 1995. The heating energy consumption includes space heating and the energy consumed in providing hot water. Annual consumption figures were corrected for weather conditions. The monthly values were also corrected, because the different reference periods consisted of only 4 to 5 months. Changes in heating energy consumption were examined regarding the changes in consumption of reference periods in each household.

Consumption levels of household electricity and water were calculated using information given by households in the inquiry and the interview about their frequencies and methods of performing housework, including the appliance, its type and properties. This information was connected to measurements in laboratory using wasting, saving or adequate ways of consuming electricity or water(, which were covered in the advice material).The point was to calculate adequate (not saving or wasting) consumption in proportion to household size and housework . This calculation was used when determining potential saving for each household, though it was not possible to calculate water saving potential, mainly because WC pan consumption was not asked or estimated. The difference between the calculated and measured total household electricity consumption was construed as a potential of saving. Changes in electricity and water consumption were examined regarding to saving potential in each household. The reference periods differed for space heating and for household electricity and water consumption (figure 2-2.).

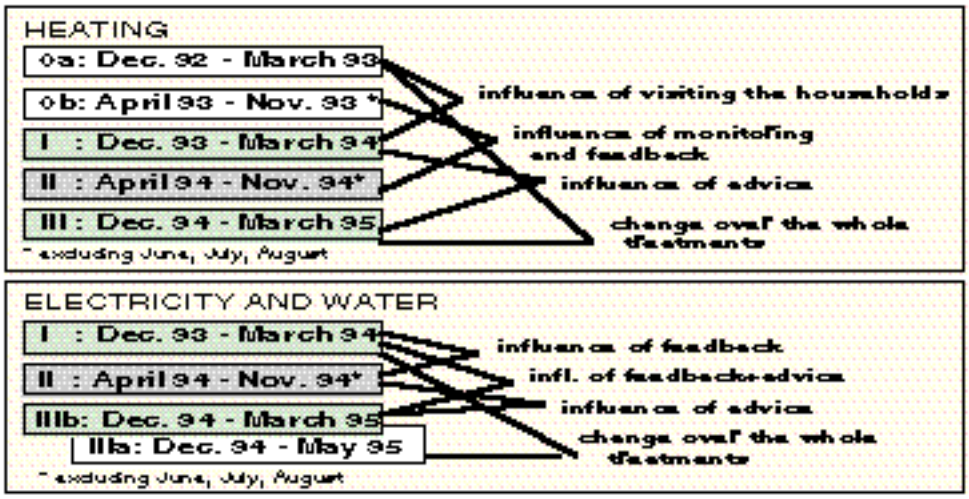

Figure 2-2. Reference periods.

2.2.2 Statistical Analysis

The parameters used to describe the groups and changes within them were mean, median, quartiles and box-plot. Methods for comparing possible changes within the groups after different treatments were mainly one- and two-way variance analysis followed by Duncan´s test for comparing the pairs. Correlation matrix and analysis were used to examine the results approximately.

3. Results

3.1 Willingness to Save Energy

The most common sectors in which the households were most eager to save energy were: (1) lighting and lamps (50 % of households), (2) sealing of windows and doors (37 %), (3) lowering the room temperature (33%), (4) changing habits in the use of fridge and freezer (28 %) and (5) reducing the ventilation (25 %). In the case of water consumption, 51 % of the households were willing to save water and the energy of hot water by changing their personal hygiene habits. At the same time, 34 % of the households were not prepared to lower the room temperature. About half the households had room temperatures of 20-21 ∞C already.

Economic reasons provided the motivation for saving energy in 68 % of the households of this study, environmental reasons being 20 %.

Advice dealing with some aspect of saving electricity was sought by 50 % of households. Households were most interested in material on new light fittings and saving energy in lighting. Advisory material dealing with heating energy and heating equipment was requested by 41 % of the households, especially on how to control the heating devices. 18 % of the households wanted to get advice on ventilation systems.

3.2 Opinions About Feedback and the Advisory Material

Over 40 % of households in the three experimental groups reported that the feedback made them think about their consumption, after they had received the feedback material for three months. 13 % of the households even altered their habits as a result of the feedback material, usually in order to save electricity or water. 98 % the households were very satisfied with the feedback material.

The advisory material was evaluated as “good or quite good” by most of the households. Almost all the households watched everything which was on the video tape, (almost 2 hours), although they were delivered a list of

parts important for them. The use of technical equipment was found to be easier to understand when the advisory material was given as videotape.

3.3 Changes in Energy Consumption Habits

Many households in each experimental group tried to do something to save heating energy, electricity and water even though they didn't get any kind of advice (Table 3-1).

The most common energy-saving measures applied in all the groups were: turning off the lights in empty rooms (54 % of the households), reducing water consumption relating to personal hygiene (29 %), lowering the room temperature (27 %), dressing more warmly (27%) and paying attention to the thermostatic radiator valve settings (23%) so that furniture or curtains did not prevent them from affecting the temperature.

Table 3-1. Some figures describing the number of energy saving measures in the groups.

		Group 1	Group 2	Group 3	Group 4
Number of households	heating	74%	67%	76%	65%
that took energy saving	electr.	81%	84%	81%	77%
measures, % of group	water	70%	55%	41%	50%
Average number of measures	heating	2,6	1,9	2,1	2,1
(in those households who	electr.	4,1	4,0	2,9	3,7
changed their habits)	water	2,6	2,1	1,9	2,1

There were no remarkable differences between the groups in choosing energy saving measures. In the choice of energy saving measures the attitude category which was already considered the most economical type at the outset applied energy-saving measures more often than the other attitude categories. The number of measures in a single household was also bigger than in the other attitude categories.

3.4 Results of Changes in Heating Energy Consumption

The specific heat consumption in each experimental group was quite low, 38,3-41,5 kWh/m3,year, which was 10 % lower than that of the blind control group. The mean specific heat consumption decreased in each experimental group during the first year of the study. The decrease in the mean specific heat consumption of all the participating households was 6 % from year 1993 to year 1994 (table 3-2). At the same time the specific consumption in the blind control group either decreased by only 1-2 % or increased. Participating in the energy study made these households save heating energy.

Table 3-2. The mean specific heat consumption, median change (%) in specific heat consumption and in heating energy consumption during different treatment periods. A negative value means energy saving.

Experimental group	1993 specific consump	1994 specific consump	change in heat consump from 1993 to 1994	effect of visit and monitor. of own consump. periods (compared: I and 0a)	effect of feedback and monitor. (periods compared: II and 0b)	effect of advice, feedback and monitor (periods compared: III and I)	effect of the whole monitor. time (periods compared: III and 0a)
	kWh/m^3	kWh/m^3	% 1993	% of 0a	% of 0b	% of I	% of 0a
Group 1(video)	41,5	37,6	-9	-6	-9	1	-9
Group 2(literature)	41,4	38,5	-7	-7	-6	2	-3
Group 3(only feedback)	40,7	39,1	-4	0	-3	1	2
Group 4(nothing)	38,3	37,1	-3	-4	-2	5	-2
All households	40,3	37,9	-6	-5	-5	2	-3

At the beginning, when the households were only checking their consumption, all except group 3 were saving energy compared with the same months of the previous year. When feedback material was sent to the groups 1, 2 and 3, the households in group 3 also began to reduce their heating energy consumption.

After the advisory material had been supplied, the heating energy consumption did not decrease any more compared with the same months previous year, when the researchers had just visited the households. On the contrary, a slight increase in consumption can be observed. In group 4 the median increase in heat consumption was 5 %. Although the statistical analysis did not reveal any differences between the groups in any of the different treatment periods, the result gives the impression that the households in group 4 got used to meter reading. Since they were not subject to any kind of “alerting” action, it may be that the idea of energy saving was forgotten.

The specific heating consumption decreased 6 % from 1993 to 1994. That means a saving of about 1100 kWh a year in the households in this study. The sum saved was only about 170 FIM. Since the main motivation for saving energy was money, this explains the small saving percentages in heating.

3.5 Household Experience

3.5.1 Potential for Saving Household Electricity

The saving potential of electricity lay between 83 and 125 kWh/ month, and 11-16 % of the monthly consumption (table 3-3). In other words, the households were able to decrease their electricity consumption by 11-16% on an average without compromising over their level of comfortable or changing towards extremely saving habits. One consequence of the way the calculation was made was that some households were already consuming less than the moderate level, showing a negative potential. The high individual maximum potentials were due to excessive heating by electricity; floor heating or heating some spaces with batteries/coils. Group 4 showed less saving potential than the other groups.

Table 3-3. Saving potential of household electricity, kWh/month, and its % share of the measured monthly consumption (average December 1993 - April 1994)

Group	Md kWh	%	Mean kWh	%	SD kWh	%	Min kWh	%	Max kWh	%
1. (video)	79	*12*	125	*14*	203	*22*	-91	*-13*	759	*67*
2. (literature)	98	*16*	115	*14*	150	*17*	-45	*-10*	650	*48*
3. (only feedback)	113	*18*	114	*16*	101	*12*	-68	*-13*	443	*41*
4. (nothing)	67	*14*	83	*11*	134	*19*	-206	*-34*	458	*40*

HVAC-systems consumed on average 37 - 163 kWh/ month, and 9-24 % of measured monthly electricity consumption. Households with minimum consumptions had only water pumps etc. while those with maximum consumptions also had floor heating by electricity, resistor heating elements in the ventilation system, etc.

3.5.2 Household Electricity and W ater Consumption

In addition to electricity consumption water consumption was monitored, too, partly to explain heat consumption (warm water was heated by the same district heating) and partly because their consumption patterns originates similarly.

Tables 3-4 and 3-5 present the consumption of household electricity and water and the changes between periods. Apart from heating, it was not possible to obtain monthly household electricity and water consumption figures for the preceding years. What is important is the difference between groups at each stage; not the change from one period to the other. Differences in consumption between the groups were tested at each stage. The stages are:
*change from period I to period II (Dec. 93 - March 94 to April 94 -Nov. 94)
*change from period II to period IIIb (April 94- Nov. 94 to Dec. 94- March 95)
*change from period I to period IIIa (Dec. 93- March 94 to Dec. 94-May 95)

As regards the changes from period I to period II, electricity consumption in group 4 decreased statistically significantly less than in groups 1 and 2. At this stage the treatment of groups 1 - 3 was the same. They had received monthly comparative feedback since period II.

Table 3-4. Consumption of household electricity and the change as % between periods.

	Consumption, kWh / household / month				Change in consumption, % of preceding period		
Period	I 93.12-94.03	II 94.04-94.11	IIIa 94.12-95.05	IIIb 94.12-95.03	II-I % of I	IIIa-II % of II	IIIb-I % of I
Group 1 (video)							
Mean	729	559	615	669	-21	10	-7
Md.	764	556	618	662	-18	11	-5
Group 2 (literature)							
Mean	692	547	594	647	-19	9	-5
Md.	665	552	574	617	-15	8	-3
Group 3 (only feedback)							
Mean	699	567	604	650	-17	7	-5
Md.	677	564	584	615	-15	4	-4
Group 4 (nothing)							
Mean	635	524	572	616	-14	9	-1
Md.	567	542	577	611	-13	8	1

In period III groups 1 and 2 got focused advice. All the groups increased their electricity consumption. There were no statistically significant differences between the groups from II to IIIa.

All the groups consumed less electricity in period IIIb than in period I. The consumption of group 1 decreased the most, 7 % (59 kWh/month) and that of group 4 the least, 1% (18 kWh /month). As mentioned, group 4 showed the least saving potential. The changes in electricity consumption of the groups 1 and 3 were statistically significantly different from group 4.

Between periods I and II and between periods I and IIIb (the same months) the higher the electricity saving potential ($p < 0.0019$) was, the more the electricity consumption decreased. By contrast, there was a negative correlation in the changes between periods II and IIIa ($p < 0.05$). After the advisory materials had been supplied, the higher the electricity saving potential was, the more the consumption increased, but still leaving a significant decrease in electricity consumption compared with the consumption before any feedback.

The consumption of water (m3) was always converted into specific water consumption (l /person/24 hours) according to the monthly reports from the households. The absence of a family member or visitors were taken into account. In Finland, 155 l/person/24 hours is regarded as a moderate specific water consumption.

Specific water consumption of the group 4 remained the lowest in spite of some increase during the stage III. Groups 1 and 2 showed a slight decrease towards the end of the stage III. There were no statistically significant differences in the change of specific water consumption between the groups at the different treatment periods.

Table 3-5. Specific water consumption, and its change as a % between the periods.

	Consumption, l / person/ 24 h				Change in consumption, % of preceding period		
Period	1 93.12-94.03	II 94.04-94.11	IIIa 94.12-95.05	IIIb 94.12-95.03	II-I % of I	IIIa-II % of II	IIIb-I % of I
Group 1 (video)							
Mean	141	140	137	131	1	0	-4
Md.	122	127	133	128	-3	-1	-2
Group 2 (literature)							
Mean	124	132	126	122	7	-3	0
Md.	119	128	122	119	10	-2	-2
Group 3 (only feedback)							
Mean	129	135	133	130	4	-1	1
Md.	127	129	128	125	4	-1	3
Group 4 (nothing)							
Mean	114	114	117	115	0	3	1
Md.	115	114	124	122	3	- 2	3

4. Feedback of District Heating Consumption to Customers in Finland

In the following chapter the Finnish District Heating Association describes its development work on improving the feedback reports.

4.1. Follow-up of District Heating Consumption

The Programme on Energy Conservation, made by the Finnish Council of State in 1992, wants to give more information to customers in order to increase energy efficiency. A follow-up of district heating consumption has been found a good method of generating greater energy efficiency. Most of the Finnish energy and district heating companies have given feedback to their customers since the middle of 1980´s. Some of them gave feedback already in the beginning of 1970´s. About 85 % of the Finnish district heating customers nowadays receive feedback on their consumption. These reports have varied very much in different cities and customers have found them difficult to understand.

The Finnish district heating field has developed means for energy efficiency. One of the means was to improve feedback reports to district heating customers. An inquiry of customer needs was made by the Finnish District Heating Association (FDHA) in the spring 1993. In the inquiry the customers were asked what kind of services they are interested in getting from district heating companies. More than 60 % of the answers expected feedback on district heat consumption.

4.1 Feedback Reports

As a result of the inquiry the Association gathered a group for developing feedback reports and prognosis of district heating costs. The group has published a report of their work. The publication consists of information on feedback and energy efficiency and models of reporting. It was delivered to the members of the Association and also to ADP companies to work it up. The Association recommends that consumption feedback be given to customers once or twice a year. This kind of service is included in the costs of district heating. If feedback is to be given more often then customers must pay for it.

Information in the feedback report must be very clear and understandable and is best presented visually in graphs, tables and figures. Graphs were put at the end of the report in order they could be detached and for example fastened to bulletin boards of the apartment blocks. Estate managers are responsible for providing consumption feedback to inhabitants in the apartment blocks.

It was recommended that there ought to be six fields in the report form; invoicing address, general information to the customer, consumption information, district heating fees, further information and a field for actual issues.

In the field of general information consumer can see a customer code, the site of the building, the building volume in cubic meters and in square meters, the number of buildings, apartments, inhabitants or business and office rooms.

Consumption information is given in tables and graphs. Information is collected over five years, if possible. The table and graph has to show invoiced consumption (MWh), a normal year temperature adjusted consumption (MWh) and amount of heating energy consumed by buildings (kWh per cubic metre per year). In addition, information about heating energy consumed by other similar buildings in the city (kWh per cubic metre per year) and the optimum consumption of the building are given.

The field: “district heating fees” consists of energy fee, effect fee or water flow fee and total costs FIM per square metre of the building. The fifth field consists of further information like a cooling of district heating water, average temperature of the reporting period, degree day and share of tap water consumption. Field six is reserved for actual information to customers, for example, exceptional weather conditions and consequent variations in consumption.

4.2 Cost Prognosis

Prognosis of district heating costs for the next year should be sent to customers annually in the middle of September. This can be written as a short letter where the costs both of energy fee and effect fee and total costs are given. The prognosis can also be shown as a table, in which form the information is given monthly. The table

shows average temperature, energy consumption (MWh), energy fees, effect or water flow fees, total costs and costs both FIM /cubic metre and costs FIM/ square metre.

Many of the members of the FDHA have adopted feedback models. Some of the ADP companies have also developed models for data based form.

4.3 Responsible Persons

In order to secure the follow-up of the heat consumption, the group also recommended that inhabitants of the apartment blocks could choose a person, who would be responsible for heat efficiency. Energy and district heating companies ought to coach these persons in their work. Those persons could intensively follow up the heat consumption and notice troubles with equipment or heat delivery. He or she could also organise repairs, remodelling or renewal of equipment and check the correct dimensioning of equipment. Responsible persons contact energy and district heating companies in order to have more advice or information of district heating.

5. Conclusions

As a result of the way of the households were recruited, they were highly motivated. Many of them had already struggled to save energy. At the beginning, two thirds of the households were willing to save energy in some way. The households were eager to save energy by changing their lighting, sealing windows, lowering the room temperature and reducing their water consumption by changing their personal hygiene habits. Half of the households wished to get advice on the usage of electricity, 40 % on space heating and things connected to it, 18 % on ventilation and 12 % on usage of water. Economic reasons provided the motivation to save energy in the households.

The mean specific heating consumption decreased in each experimental group during the first year of the study. The decrease was 6 % from 1993 to 1994. At the same time the specific consumption in the blind control group decreased by only 1-2 % or increased. The average saving was about 1100 kWh/per year. As a result, it seems that participating in the energy study made these households save heating energy.

The heating energy consumption of the households decreased during the different periods examined, except after receiving the advisory material. The feedback material made the consumption visible, so the advisory material did not have any further influence. Although there were no statistically remarkable differences between groups in the savings, the values nevertheless give the impression that households in group 4, which did not get any material during the study, had lost interest in saving energy.

50 % of the households began to turn off the lights in empty rooms and 29 % of them reduced the water usage in personal hygiene. The room temperature was lowered and the dressing habits changed in 27 % of the households. 23% of the households moved curtains and furniture so that the thermostatic radiator valves were not obstructed.

The calculated electricity saving potential lay between 83 and 125 kWh/month, and 11-16 % of the monthly consumption. HVAC-systems consumed on average 13-16 % of measured monthly electricity, so a big share of the electricity consumption was caused by factors initiating from reasons other than conventional household electricity.

All the groups consumed less electricity in period II, when groups 1,2 and 3 received feedback and group 4 sent their consumption values, compared with period I, when all the experimental groups only sent consumption values to the researchers. The change in electricity consumption of group 4, decreased statistically significantly less than that of groups 1 and 2. After delivering focused advice there were no statistically significant differences between the changes in electricity consumption of the groups.

When the electricity consumption after focused advice was compared with consumption of same months previ-

ous year, all the groups had consumed less electricity, even those without advisory or feedback material. The change in electricity consumption of group 4 was statistically significantly less than that of groups 1 (video) and 3 (only feedback). The results give an impression, that the feedback material had the greatest influence on consumption.

Finnish District Heating Association has developed feedback material models for district heating companies, in order to get the feedback more customer-friendly.

References

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