Power efficiency classes for households – monitoring long-term effects of a power saving intervention

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Abstract

In this contribution, we will present insights from the implementation of an integrated approach to power saving. Based on comparative feedback, the project "power efficiency classes for households" is designed to help households to evaluate their total power consumption and to plan and implement priority saving measures. The approach aims at jointly overcoming various barriers: lack of motivation, lack of knowledge about total consumption and most effective measures as well as lack of planning, feedback and appreciation. It features a communication campaign with four basic elements: a classification system for comparative feedback, a power audit, various communication tools supporting self-monitoring of householders, and a certificate reporting the effects of the power saving efforts at the end of the intervention period. Drawing on a field trial with 98 households in two regions of Germany, we will present some results from an exemplary implementation of the approach. Data sources are consumption measurements at the end of the intervention period, two surveys in the middle and at the end of the intervention period, qualitative interviews with participants and an additional survey one year after the end of the field trial. They show average savings of 5 % (and more in "high consumption" households) at the end of the trial. Savings even increased further after the field trial was terminated.

Introduction

The saving of electricity is an essential requirement for the transformation of the energy system (SRU 2011). Even small changes in yearly electricity consumption have a strong impact on scenarios for the energy transition (Janzing 2011). In the EU 28, private households consumed 29 % of the total electricity in 2014 [Own calculation from Eurostat]. This makes them a relevant target group for measures directed at electricity savings. Germany's contribution to EU household electricity consumption is the second largest, amounting to 17 % of the EU total (ebd.). Germany is therefore a market in which measures to promote household energy savings may be tested.

BARRIERS TOWARDS ENERGY CONSERVATION

German Federal Government has set a target to reduce power consumption by 10 % in 2020 and 25 % in 2050 (base year: 2008). Private households account for about 25 % of total electricity consumption. They have a theoretical savings potential of up to 65 % (Fischer et al. 2016: 4–5). Actual power consumption in households fell by about 5 % between 2008 and 2015 and is, with 132 TWh/a in 2015, roughly on track (Arbeitsgemein-schaft Energiebilanzen 2015). However, with a marked rise in 2015 the trend is not yet stable, and the savings are still a far cry from what would be possible.[1]

There are several reasons for the gap between the potential and actual savings (for a review of typical barriers see Fischer et al. 2016: 535ff.). At the very basis lies disinterest in power

1. For example, according to Grießhammer et al. (2012), an ideal household – equipped with the most power-efficient products available today – would consume only around 1,145 kWh, with equal comfort, amounting to theoretical savings potential of approximately 65 %. In addition, by behavioural measures alone, around 1,100 kWh could be saved without any investment in new appliances.

saving. Power consumption is "invisible", and the practice of yearly billing gives consumers only a poor and late feedback about actual consumption. Most consumers pay their power bill automatically, and hence do not take notice of their power consumption figures. In addition, electricity savings show, at best, in the private area and do therefore not have a prestige function (Fischer 2008).

Furthermore, relevant saving measures are often little known. Publicly available energy-saving advice is often not focusing on priority measures, giving tips with small effects (e.g. avoiding standby, which has already been restricted by Ecodesign to 0.5 W per appliance). More effective measures are less well-known (e.g. the fact that water saving shower heads contribute to significant power savings if water is heated electrically), (Belz and Bilharz 2007; Bilharz 2008).

Also, consumers find it difficult to relate individual savings to their total power consumption or cost, which makes changes seem less relevant. They also lack the routines for long-term investment planning. As a result, the cost advantages provided by choosing efficient appliances or replacing outdated ones are seldom explored. Instead, households focus on purchase cost. Also, the implementation of advice is often seen as too time-consuming and costly. In a liberalized energy market, switching the supplier may be an easier way to save costs.

The two main energy-saving advice campaigns in Germany are also not ideally placed to effectively target the electricity consumption of middleclass households, a group with large power saving potential (Fischer et al. 2016, chapter 4.3). The campaign "Stromspar-Check" (www.stromspar-check.de/) addresses exclusively low-income households. The offer from the Consumer Centers (www.verbraucherzentrale-energieberatung.de) treats electricity consumption in a relatively cursory manner with a stronger focus on heating and insulation.

The project on power efficiency classes for households was set up as an integrated approach overcoming some of these barriers to full exploitation of their power saving potential, targeted in particular towards households with an average or high electricity consumption.

Promoting household energy saving: state of the art

In various research contexts, intervention measures aiming at reducing household energy or power consumption have been explored (Abrahamse et al. 2005; Duscha et al. 2006; Osbaldiston and Schott 2012; RAND 2012; Scharp 2011; Darby 2010; Martinskainen 2007; Delmas et al. 2014; Karlin et al. 2015). We will shortly present those which got applied to our approach, elaborating a little more on feedback, as it is a core element of our approach.[2]

Information provision can mean a wide range from general media campaigns to personal in-situ energy audits. It aims at a reduction in consumption by increasing awareness for energy related problems or solutions (Abrahamse et al. 2005: 276f.). Delmas et al. (2013: 735) show that general information campaigns with only little involvement (i.e. dissemination of energy saving tips) are not effective, whereas those with a high degree of involvement (i.e. home energy audits) can lead to reasonable energy savings.

Economic incentives, like for example additional rewards for savings or replacement bonuses for appliances, are generally positively evaluated (Abrahamse et al. 2005; Scharp 2011). However, their success is strongly dependent on the public communication of the funding programme. Duscha et al. assessed a participation rate over 5 % as high and under 0.2 % as low (Duscha et al 2006: 104). Furthermore, these measures are likely to attract free-riders, and they do not reap the full savings potential of a household, as they only aim at individual appliances.

Goal-setting helps to target the effort and can be an effective strategy if combined with further measures, especially feedback (Abrahamse et al. 2005: 276; Karlin et al. 2015: 1220). Karlin et al. (2015: 1219) emphasize that energy feedback combined with goal-setting is more effective than a feedback alone.

Feedback gives households information on their consumption compared to a standard (past usage, peer usage, or goal) (ebd.: 1211). Only when a discrepancy between feedback and standard is recognized by the consumer, a behaviour change is possible (ebd.: 1206). *Historical feedback* informs households of their power consumption over time and operates by providing a personal norm (Duscha et al. 2006: 114). *Comparative feedback* (Abrahamse et al. 2005: 279; Duscha et al. 2006: 115; RAND 2012: 6) compares household consumption to other households, in order to motivate households with above average consumption to save power by providing a descriptive norm (Roberts und Baker 2003: 11). *Feedback* using a *goal comparison* shows the recent consumption compared to a goal and operates through motivation and awareness processes.

In general feedback interventions have induced power savings from 5 up to 12 % (Fischer 2008: 87; Karlin et al. 2015: 1219). Savings up to 20 % are reported especially in older studies (Scharp 2011; Fischer 2008; Darby 2010; Abramse et al. 2005; Martiskaien 2007; Rand Europe 2012). Studies from 2000 on tend to report lower savings more in the order of 3 % (RAND Europe 2012; Intelliekon 2011). The validity of the older studies for today's situation is questionable – e.g. given the fact that appliances were much less efficient back then. Also high quality studies (e.g. including a control group) report lower savings than such with a lower quality (Delmas et al. 2013: 734).

The effectiveness of feedback depends on various circumstances (e.g. frequency, duration, combination with other interventions) (Karlin et al. 2015: 1205). First, it has a temporal dimension. In order to increase their effectiveness, feedback interventions should be given regularly, relate as closely as possible to concrete actions, and last over longer periods of time (Karlin et al. 2015: 1221; Allcott und Rogers 2014: 3034). Even then, the feedback receiving person tends to stop engaging with feedback after a certain period of time and energy savings decline (Karlin et al. 2015: 1221; Intelliekon 2011). A gradually decline is also recognized after the end of the feedback intervention (NMR Group 2016: XII), even after a two year lasting feedback intervention (Allcott und Rogers 2014: 3034). These results indicate that feedback alone has only limited impact. Therefore, feedback interventions should be combined with other measures, especially in-situ energy audits and goal-setting (Scharp 2011; Schleich et al. 2011; Karlin et al. 2015: 1220).

2. A shortcoming of the review studies presented here is that they focus on overall savings and do not systematically distinguish between interventions targeting everyday behaviour, and interventions targeting investment, types of behaviour with quite different restrictions and preconditions.

Table 1. Barriers and instruments.

Addressed Barriers	Mechanisms to overcome	Applied Instruments: Classification system for comparative feedback (for households energy efficiency)	Home power audit	Investment grants	Self-monitoring tool providing historical feedback (self monitoring tool)	E-Mail Newsletter	Certificate of efforts
Disinterest in power saving	Make energy consumption visible	x	x		x		x
	Raise interest	x					
	Provide problem awareness for high power consumption		x				
	Recognition of saving achievements						x
Lack of knowledge on savings	Show energy saving opportunities		x			x	
	Reduction of complexity through prioritized saving opportunities		x				
Fixed Routines	Establishing energy saving routines	x			x		
	Maintain attention for energy conservation				x	x	
Lack of motivation	Provide motivation by way of competition	x					
	Provide motivation by way of goal-setting		x				
	Illustrate cumulative (financial) effect of minor energy savings		x		x		
Restraint acquisition of highly efficient appliances	Overcome first cost bias, illustrate life cycle cost		x			x	
	Provide financial support to enable or facilitate investment			x			

Source: own illustration.

This is in line with studies, suggesting that a mix of interventions is most successful.

"Power efficiency classes for households" – an integrated approach

The research project "Power efficiency classes for households"[3], running from April 2013 to July 2016, was funded by the Federal Ministry of Education and Research and conducted by the research institutes "ISOE - Institut für sozial-ökologische Forschung" and "Oeko-Institut e.V.". Partners were energy suppliers Badenova AG (Freiburg) and Entega GmbH (Darmstadt), the consumer centre North-Rhine Westphalia, appliance manufacturer BSH, OSRAM GmbH, and online energy advice provider co2online. Its main objective was to develop an integrated approach helping households to evaluate their total power consumption and to plan and implement priority savings. The approach aims at jointly overcoming multiple barriers towards energy conservation identified above (Fischer et al. 2016). The main elements of the approach are a classification system, providing comparative feedback, a home energy audit, communication tools and financial subsidies for replacing poorly efficient appliances. Table 1[4] gives an overview of instruments applied and their operating mechanisms. A more comprehensive description of the instruments is given in the following section.

THE CLASSIFICATION SYSTEM "POWER EFFICIENCY CLASSES OF HOUSEHOLDS"

Feedback draws attention to the own consumption. If it provides a social comparison to other households, it can create problem awareness for unnecessarily high consumption, raise interest to motivate households to start searching for saving potentials. The classification system of the power efficiency classes assigns a class to each household, based on its annual power consumption. 20 household types are created from three basic factors that modulate consumption: type of building (multifamily or detached/semi-detached house), type of hot water generation (electric or non-electric) and number of people in the household (one to 5 and more). For each type, 7 power efficiency classes were defined.[5] For this purpose, 73,000 data sets about annual household power consumption in 2013, obtained from co2online (www.co2online.com) were split into quantiles. Each of the lower consuming six classes encompasses 12.5 % of the households and the seventh class comprises 25 % as shown in Table 2. For example, a cut was made after the 12.5 % of least consuming

3. www.stromeffizienzklassen.de

4. Investment grants: Option to buy a highly efficient cold appliances or tumble drier at reduced price, offered by partner BSH.

5. The number of seven classes was chosen for various reasons. It reminds the familiar EU Energy label, it is a number that offers sufficient differentiation without being overcomplex, and, as an uneven number, it offer a "middle" or "neutral" class.

Table 2. Distribution of households across power efficiency classes.

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Total
% of households	12.5	12.5	12.5	12.5	12.5	12.5	25.0	100

Source: own presentation.

Figure 1. Self-analysis tool to determine power efficiency class. Step 1: Type of house, Step 2: Hot water generation, Step 3: Household size, Step 4: Power consumption in kWh/year. Source: Own illustration.

households, and the consumption of the household at this point defined the upper limit of Class 1, with a rounding factor.[6]

The classification system is provided in form of an online calculator, or of a printed table in which households can determine their efficiency class in four steps based on their household type and their power consumption in kWh/a (Figure 1).

POWER SAVING AUDIT

The audit is designed to help households identify and prioritize saving potentials in order to improve their power efficiency class or reach a self-defined percentage savings goal in annual electricity consumption[7]. It provides an analysis of the power consumption of an individual household and gives context specific recommendations for energy saving actions which are adapted to the situation of an individual household. In cooperation with the Consumer Center North-Rhine Westphalia, a personalized audit was developed based on a standardized Excel tool that also allowed for data collection. It was carried out by professional energy advisors provided and financed by utility partners. It consists of seven main steps:

1. Survey of basic household data, annual power consumption, and assignment of a power efficiency class;
2. Survey of home appliances, their documented or estimated input power and their patterns of use, to calculate annual power consumption per appliance and area of activity (e.g. "cooling and freezing");
3. Evaluation of each area of activity, by comparing the individual power consumption to an average for this household type, and assessing whether there is need for action.
4. Setting a personal savings goal, e.g. change of class or a percentage goal;

6. There were two reasons for having a bigger class at the end. First, in order to have a sufficient number of households in that class. Secondly, class boundaries were designed to enable people, if possible, to "move up a class". We reasoned that high savings are easier to attain for high consumers, therefore "moving up a class" should require more savings in class 7. However, one of the results of the project was that it had actually become too hard to "move up", so classes were adjusted o be of equal width.

7. The annual power consumption of the last billing periods prior to the intervention was recorded at the power saving audit. This value was used as benchmark for individual saving goals and the calculation of savings at the end of the intervention period.

5. Recommendations for priority measures to achieve the goal and evaluation of their savings potential in kWh and Euro;
6. Determining whether the household qualifies for the appliance exchange program;
7. On-site installation (energy efficient light bulbs sponsored by OSRAM).

As a follow-up, households received a standardized two-page report, summarizing main results and recommendations in a graphically appealing manner.

When the power saving was implemented in the field, however, it turned out that goal setting was not implemented as planned. In the debriefing session, energy advisors reported that they had felt that a discussion of savings goals would be too intruding and had mentioned the topic only very cautiously, if at all.

SELF-MONITORING TOOL

To counteract a decay of saving efforts over time, a tool for monitoring power consumption on a monthly basis was introduced. The monitoring could be provided either offline in a booklet and/or using the online tool "Energiesparkonto" ("Energy saving account") in cooperation with co2online. The booklet and the account invite householders to observe their individual progress (self-monitoring), tracking their own energy consumption by reading their meter and inserting the data in the booklet or the energy saving account. A monthly e-mail newsletter reminded participating households of the monitoring, kept them committed and provided additional information on energy saving.

CERTIFICATE "SAVING POWER WITH CLASS"

The certificate reports achievements in energy savings and functions as a symbolic award. It is based on the meter reading at the end of the intervention period. It provides information on the energy consumption during the treatment period as compared to the consumption in the previous period. It also links present and previous consumption to the respective power efficiency class, providing both historical feedback on personal progress and social comparison mediated by the power efficiency class.

OVERALL COMMUNICATION CAMPAIGN

An overall communication campaign was designed by a professional marketing agency and tested in two focus groups. The campaign provides a common framework for the different intervention tools. It was directed towards the target group of average consumers and created in a sober and factual way. The selected claim – "Klasse Strom Sparen" – could be translated to "Saving power with class", whereby 'Klasse' in German can mean 'great' as well as 'category'.

Field trial "Klasse Strom Sparen" ("Conserving electricity in a classy way")

METHODOLOGY AND STUDY DESIGN

The various interventions of the campaign "Klasse Strom Sparen" were implemented and evaluated in a field trial. The study was designed in a way creating a setting close to everyday life conditions, giving particular attention to the investigation of long-time effects. In addition, the study aimed at identifying the most promising areas and measures for power saving to be targeted by advice campaigns. The intervention group was selected according to socio-demographic criteria and the level of power consumption. Due the limited size of 98 participating households, the impact of the intervention was assessed against the level of power consumption in the pre-treatment period (historical comparison). As the intervention group was not randomly selected, a comparative design, including a control group without treatment, would have required to enroll "siblings" of the participating households for the non-treatment group, a task that could hardly be realized. In order to avoid a distortion of results, savings of the treatment group were controlled against external effects having a potential impact on the level of power consumption (see chapter "Results").

SAMPLE AND DATA BASE

The field trial was conducted with 98 participating households in Freiburg and Darmstadt between June 2014 and June 2015. Households were recruited via the project website, press releases and communication of partner utilities with their clients. Of 246 interested households, 110 were selected based on the following criteria: household type, socio-demographic data, and power efficiency class. Of those invited households, 98 finally participated in the field trial. 85 households remained until the end of the field trial (see Table 3).

The households received the power audit between September and December 2014, followed by a six to nine month period where they monitored their power consumption monthly, online or offline, and could apply for an investment grant for

Table 3. Participating households in the field trial.

Age group / Household type — Power efficiency class	Young Adults (< 30 yrs)		Medium age: (31–45 yrs)		Medium age: (46–60 yrs)		Elder (> 61 yrs)		Total
	1–2 Pers	3+ Pers	1–2 Pers	3+ Pers	1–2 Pers	3+ Pers.	1–2 Pers	3+ Pers	
Low	1	1	3	8	3	4	2	0	22
Medium	2	0	5	10	6	7	7	0	37
High	1	1	4	8	6	9	8	2	39
Total	6		38		35		19		98

Source: Own presentation.

exchanging an appliance if they qualified. After a final meter reading at the end of May 2015, they received their certificate.

Different empirical methods and data sources were used, applying qualitative in-depth interviews and standardized surveys (see Table 4). A telephone survey was conducted at the of the intervention period in summer 2015. A follow-up survey was carried out in April/Mai 2016, one year after the end of the field trial.

Results of the field trial

ELECTRICITY SAVINGS

Changes in power efficiency class and electricity consumption

At the end of the field trial 85 households reported their read out meter consumption. The overall distribution of these households among the different power efficiency classes before and after the intervention is presented in Table 5, showing a slight shift from the higher to the middle and lower classes.

To assess the energy savings more properly, in a first step, the household data were checked for plausibility. As a result, 15 households were excluded from the sample which showed obvious metering or communication mistakes or had experienced distorting external events such as presence of an additional person, longer absence from home, or extraordinary activities, so that 70 valid cases remained. These households achieved an average reduction of 194 kWh or 5.3 % related to their annual power consumption. Due to the small sample the statistical error is of 3–4 %. But we can still conclude that the field trial resulted in electricity savings.

Regarding the power efficiency classes, the number of households who could improve power efficiency class outnumbers the share of those who were downgraded after the field trial. More than half of the cases experienced a reduction or increase in power consumption without changing their power efficiency class (see Figure 2).

We can also identify specific groups who realized higher power savings. In particular, households in class 7 performed an average reduction of 10 %.

Long term effects

One year after the end of the field trial an additional survey was carried out. Participants of the field trial communicated their meter readings and were asked about their present electricity consumption and the further implementation of saving measures. Unfortunately only 36 households could provide valid meter readings, 26 did not report any extraordinary event and could be compared with previous savings. For these households the savings were at least constant, if not slightly increasing (see Figure 3). Average savings in this group increased from 8 % immediately after the field trial to 11 % one year later.

Priority measures

In which areas and by which measures can households particularly easily and effectively save electricity? At first, areas and individual activities with especially high power consumption were identified, using the calculated values from the documentations of the power saving audit. Top consumers turned out to be water beds (702 kWh/a on average, but only present in 9 households), refrigerator-freezers (377 kWh/a), tumble driers (336 kWh/a), cooking stoves (299 kWh/a) and refrigerators

Table 4. Data sources and empirical methods.

Source/method	Information
Documentation of the Power advice (Filled-in Excel tool; reports) (N = 98)	Power efficiency class Power consumption (total, per appliance and per area of activity) Advisor's evaluation of need for action per area of activity Advisor's recommendations and expected savings potential
Online energy savings account (CO_2 online) (N = 24)	Meter readings User activity on the web
Offline log (N = 43)	Meter readings, as reported by households
Qualitative in-depth interviews (N = 37)	Evaluation of the individual elements of the campaign Implemented measures and barriers
Standardized final telephone survey (N = 64)	Evaluation of the individual elements of the campaign Implemented measures and barriers
Standardized follow-up survey (N = 60)	Implemented measures; Meter reading

Source: Own presentation.

Table 5. Power efficiency class before and after the intervention (N = 85).

Power Efficiency Class	*1*	2	3	4	5	6	7
Prior to intervention	9	10	9	11	14	11	21
After intervention	10	11	16	14	7	11	16
Difference	1	1	7	3	-7	0	-5

Source: Own presentation.

(265 kWh/a). The relevance of tumble driers is also highlighted by a high correlation between presence of a tumble dryer and power consumption for washing and drying (r = .60, α = 0.001). However, in 28 households, lighting turned out to be top power guzzler, and in 7 households, it was TV with 958 kWh/a on average.

But what exactly causes high consumption in a certain area? Is it the type and number of appliances, the use patterns, or both? For cold appliances, there is a significant correlation between number of appliances and annual power consumption for cooling and freezing (r = .78, α = 0.001). Two thirds of the households own more than one cold appliance, almost one third even three or more. While households with one appliance have an average annual power consumption of around 340 kWh for cooling and freezing, the figure doubles or triples with two or three appliances. Furthermore, age is important for tumble driers and cold appliances, correlating even with total household energy consumption (r = 0.4, α = 0.001 for tumble driers, r = 0.22 α = 0.05 to r = 0.29, α = 0.01 for various cold appliances). Finally, use patters proved also relevant for some appliances, especially for lighting (correlation between lit area and total annual power consumption r = .65, α = 0.001) and hot water (r = .64, α = 0.01) However, results for hot water must be interpreted with care as the data basis is very small (16 cases).

After having identified the main drivers of consumption, we tried to determine which measures were attractive or at least acceptable, using the standardized telephone survey data. Figure 3 shows the share of interviewees that reported to have implemented a certain investive measure during or directly after the field trial (first wave: N = 64) or one year after (second wave: N = 60).

Small investments are most popular, followed by the replacement of a cold appliance, most probably because it was subsidized in the project. All popular measures can also be considered as having a relevant savings potential. However there are significant barriers against replacing appliances. 80 % of interviewees reject the idea of replacing an appliance that is still functioning, 67 % fear this would be uneconomical and 50 % consider the purchase costs too high. 45 % have doubts because of the resource use of a new appliance. With regard to non-investive measures (not shown in the figure), the most popular ones also relate to the relevant topics lighting and cooling (switching off lights and increasing the cooling temperature).

The results provide a basis for identifying the most promising approaches for effective power saving in households: measures that effectively target the core drivers for the applications with the highest energy consumption, and are acceptable for households. Among them are:

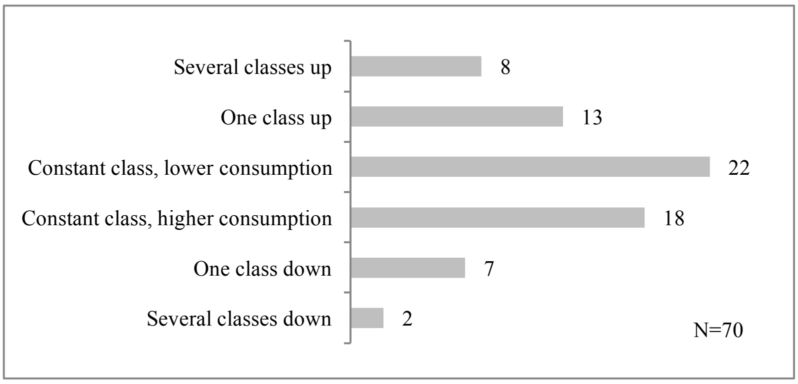

Figure 2. Changes in power efficiency class. Source: Own illustration.

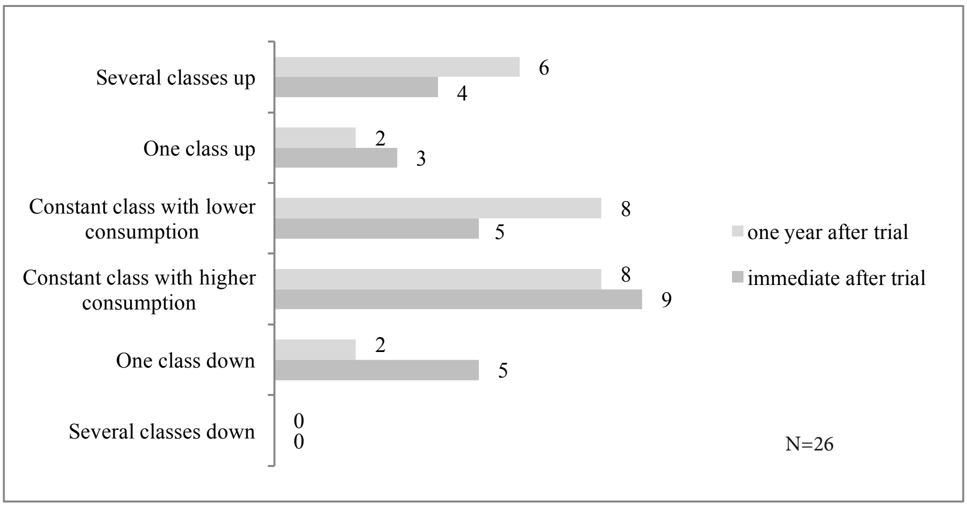

Figure 3. Changes in power efficiency class during and after field trial. Source: Own illustration.

- Hot water (if electric): Reduce hot water use; for example via water-saving showerheads. A next step could be a boiler exchange.
- Cold appliances: Put appliances out of use when not needed; adapt temperature, replace outdated appliances. For the replacement, instruments are needed to overcome the barriers, such as detailed information on the economic and ecological balance over time; financial incentives.
- Lighting: Exchange outdated technologies for LED; switch off.
- Tumble driers: Reduce use; possibly replace.
- In some cases: Switch off TV sets when not watching; consider total consumption when buying a TV set.

PERCEPTION OF THE CAMPAIGN AND THE INTERVENTIONS

After the field trial, the participants were asked about their perception of the campaign "Conserving electricity in a classy way" and their experience with the different interventions. The inquiry was carried out employing a combination of standardized and qualitative in-depth interviews.

A broad majority of participants appreciated the graphical representation of the *power efficiency classes* as intuitive (86 %) and as a helpful instrument supporting to assess the own power consumption (84 %). The classes provide a quick orientation and householders found it simple to pick up their own class from the table. The table is raising curiosity to classify one's own consumption and to compare it with other households. This effect is supported by the color scheme. In particular, the "red" classes work as a strong signal, triggering a desire to get away from the "red zone". A majority (78 %) claimed that the power efficiency classes have motivated them to become more deeply engaged with power saving issues.

The *power saving audit* was also estimated as a helpful tool. A majority (75 %) agreed (fully) that the audit provides useful information on how to save power in the own household. 70 % of the respondents agreed (completely) that the audit also provides a trigger to engage with power saving. A slightly larger proportion of respondents reported to have been motivated to implement energy saving measures which they already had in mind for a long time. But there is also a considerable group (47 %) which (completely) agreed that they did not learn anything new from the audit. At a first glance, these results may appear puzzling. But they suggest that the power audit is not only perceived as a source of information, but also as a prompt to engage with (already known) measures of power saving as is reported in the next paragraph. The personal face to face contact with the energy advisor was valued as particularly supportive. Householders appreciated both technical and behaviour oriented recommendations about the options of energy saving. Almost all respondents claimed that the audit has been very helpful for projecting and implementing power saving measures. 14 % stated that the audit provided a decisive impulse for power saving. For 80 % the audit provided an important or additional impulse.

A broad majority of householders filled in the *online energy account* or the *offline log forms*. In particular, the offline log was perceived as easy to handle. Regular metering of the own power consumption was seen as useful and motivating and a majority of participants was sure that they will continue in using a monitoring tool after the end of the field trial.

The *certificate* with annual feedback about changes in one's own power consumption was considered as motivating and stimulating. The personalized information in the certificate was valued as personal recognition of the own attempt but has no importance for peer recognition. The feedback need not to be given as a written document. It could also be provided electronically.

Overall assessment of the campaign and the different elements

The power efficiency classes system has been received very positively after the field trial. In general, 80 % of the respondents valued the campaign "Conserving electricity in a classy way"

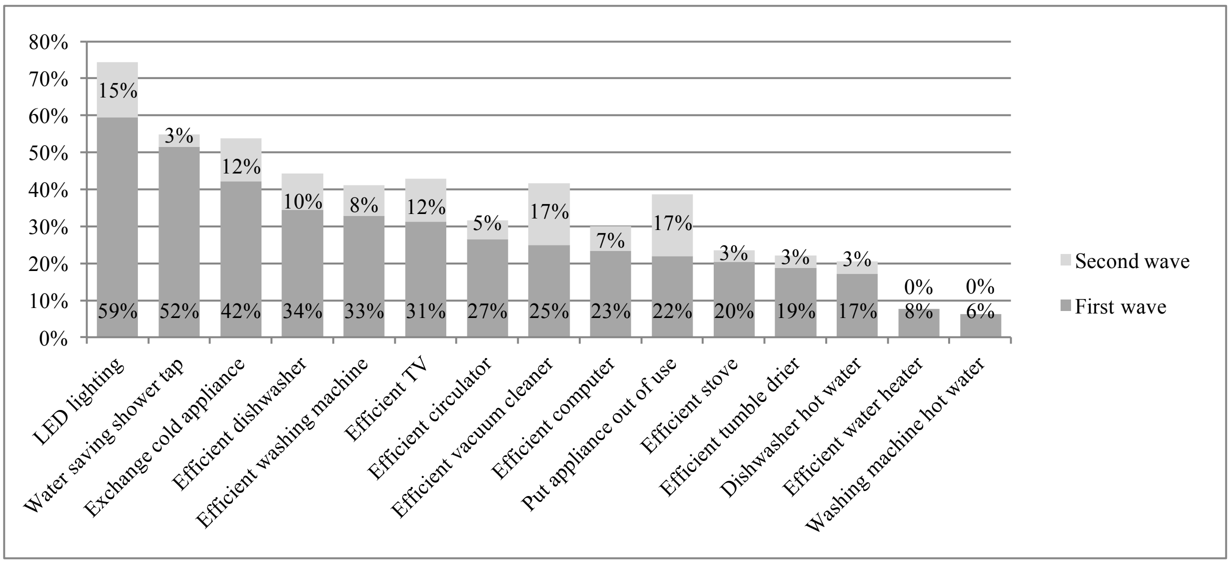

Figure 4. Reported investive measures taken by the households. Source: Own illustration.

as good or very good, the average rating was 2.1, using a scale ranging from very good (1) to poor (5). 85 % of the participants would appreciate if every household in Germany could receive a feedback in form of a personal power efficiency class. Furthermore, the inquiry gives good insights into the complex mechanism of how the power saving campaign works. The impacts of the various elements are interconnected and cannot easily be separated. For example the power efficiency classes have a motivating function. The main stimulus to identify and implement saving measures, however, comes from the power saving audit. The interviews showed that the personal communication with the energy advisor has been very effective, because many additional context specific recommendations were given during this dialogue which had not been added to the standardized summary report.

- The interaction of the different elements of the campaign is an asset of the power efficiency class approach.
- The power efficiency classes can raise the curiosity of consumers. The classes are a "door opener" and can communicate the uninspiring topic power saving and the powers saving audit. They also help the energy advisor to start communicating with the householders.
- The energy saving audit and the documentation of the results in a short report are core elements.
- The offline log and the power saving account are a helpful tool supporting self-monitoring.
- The certificate is a reasonable tool to evaluate the own saving attempts.

Follow-Up

Based on the results, the power efficiency classes were reworked. In a revised version, all classes have an equal width of 14.2 % of households. In addition, the classes were renamed with the letters A to F and the color scheme revised in order to refer to the familiar names and color coding of the EU Energy Label. The revised table was merged with the tool "Stromspiegel für Deutschland" (Power consumption mirror for Germany) which had been developed in parallel by a group of stakeholders supported by the Ministry for the Environment. The integration will allow "Stromspiegel" partners such as utilities, energy agencies, consumer centres and energy advisors to distribute the tool, greatly increasing its outreach. Currently, a follow-up project is under development, in which utilities will be contacted to discuss with them the possible use of the power efficiency classes in the communication with their clients, and regional networks will be set up to distribute the power efficiency classes and guide their readers to appropriate local offers that provide advice and support on power savings.

Conclusions and outlook

The project "Power efficiency classes for households" is the first recent field trial of such a broad integrated approach to power saving in households. A limitation is the sample. Although large for a field trial, it became considerably smaller over the course of the study due to invalid cases and dropouts. It was non-representative, and the recruitment process probably led to some self-selection. On the other hand, the selection criteria made sure that a wide range of different households was present. The variety of data sources and a triangulation of methods help to ensure validity of results, at least as an indication of what is possible. The survey results suggest that the elements of the campaign, especially the classification system, the power advice and the monitoring, fit well to the needs and expectations of private households. Power savings in the range of 5 % do not seem too impressive at first when compared with the literature. However, some considerations indicate that the results are nevertheless interesting. First, savings are remarkably stable. One year after the termination of the field trial, they are still in the same range, with even a slight improvement. Households continue to implement measures, although on a smaller scale. This is achieved only in few programs while the typical pattern for behavioural interventions is that consumption goes up again some time after the intervention (Schleich et al. 2011; Abrahamse et al. 2005; RAND 2012). Secondly, the approach seems effective especially for households in a high-energy class. Class 7 households show savings in a range of 10 %. Although this is also a familiar pattern in the literature (RAND 2012), the size of the effect is remarkable. Finally, as the goal setting was not fully implemented, its realization might yield further savings in line with review studies who find this to be a powerful tool (Abrahamse et al. 2005; RAND 2012).

From these results, some recommendations can be drawn for electricity advice programs directed at end consumers. First, the focus on low-income households in Germany should be reconsidered. Surely financial benefits of power saving are most relevant for these households. On the other hand, from a climate policy point of view, middle class households are the more interesting target group. They own a high number of appliances, often large and powerful, and occupy big living spaces, mostly in detached houses which have proven to be a relevant driver for power consumption. Therefore, absolute savings potentials are higher in these households Furthermore, the comparative tool of "power efficiency classes" has been well received and proven to provide a first incentive to think about power consumption. It is cheap and easy to realize if an infrastructure is in place to regularly update the underlying data. Therefore it would be helpful to provide such a tool in a standardized way to a broad number of households – for example via the electricity bill or as an online tool. The broader approach, including the audit, monitoring and certificate, is relatively resource intensive to implement. The issue of cost-benefit relation would suggest to focus such an approach on "heavy consumers" while cheaper and more standardized interventions such as online advice tools are offered on a broad scale to "average" households.

It also becomes clear that typically the training of energy advisors focuses on technical efficiency measures and cost-benefit calculations. They are reluctant to interfere with behaviour, lifestyles and personal choices, especially when issues of sufficiency (e.g. multiple appliances) are at stake. However, many households do appreciate this type of advice as it offers savings options with low investment cost. A dialogue over everyday practices is valued if held in an empathetic, non-patronizing way. As a consequence, training of energy advisors should enable them to discuss behaviour, lifestyles and everyday practices: they should be aware of the considerable savings potentials and develop the social competence and confidence to enter into a dialogue on such issues.

The results also suggest further issues for research. It would be interesting to compare the results to those of similar, but "leaner" approaches. One possible candidate is the "basic check", an in-house advice program conducted by the Federation of Consumer Centres in some 10,000 households per year. It also features a standardized advice session supported by a software tool, but includes less detail and does not offer comparative feedback or a follow-up process. An evaluation of this program is planned for 2017. A comparison of results could shed more light on the value of the additional elements tested in our project.

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