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A review of intervention studies aimed at household energy conservation

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Abstract

This article reviews and evaluates the effectiveness of interventions aiming to encourage households to reduce energy consumption. Thirty-eight studies performed within the field of (applied) social and environmental psychology are reviewed, and categorized as involving either antecedent strategies (i.e. commitment, goal setting, information, modeling) or consequence strategies (i.e. feedback, rewards). Particular attention is given to the following evaluation criteria: (1) to what extent did the intervention result in behavioral changes and/or reductions in energy use, (2) were underlying behavioral determinants examined (e.g. knowledge, attitudes), (3) to what extent could effects be attributed to the interventions and, (4) were effects maintained over longer periods of time? Interestingly, most studies focus on voluntary behavior change, by changing individual knowledge and/or perceptions rather than changing contextual factors (i.e. pay-off structure) which may determine households' behavioral decisions. Interventions have been employed with varying degrees of success. Information tends to result in higher knowledge levels, but not necessarily in behavioral changes or energy savings. Rewards have effectively encouraged energy conservation, but with rather short-lived effects. Feedback has also proven its merits, in particular when given frequently. Some important issues cloud these conclusions, such as methodological problems. Also, little attention is given to actual environmental impact of energy savings. Often, an intervention's effectiveness is studied without examining underlying psychological determinants of energy use and energy savings. Also, it is not always clear whether effects were maintained over a longer period of time. Recommendations are given to further improve intervention planning and to enhance the effectiveness of interventions.

Keywords: Review; Interventions; Household energy conservation

1. Introduction

Household energy conservation has been a topic of interest within applied social and environmental psychological research for a number of decades. In the 1970s, the backdrop to conservation research was the energy crisis, raising concern about a possible depletion of fossil fuels. Currently, environmental problems such as global warming, and threats to biodiversity are the main reasons for studying energy conservation (Gardner & Stern, 2002).

Households constitute an important target group, being major contributors to the emission of greenhouse gases and, consequently, global warming. In 2003, households in the United States were responsible for 1214.8 million metric tons (viz. 21%) of US energy-related CO_2-emissions. In addition, since 1990, emissions related to electricity use have risen by 2.4% annually, and those related to gas use have increased by 0.9% each year (US Department of Energy, 2005). In Western European countries, a similar trend can be observed. OECD figures on households' contributions to total energy use generally range between 15% and 20% (Biesiot & Noorman, 1999). A closer look at in-home energy use of US and most Western European households reveals that it is used first and foremost for home heating, followed by heating of water, refrigeration and freezing, lighting, cooking, and air conditioning (Gardner & Stern, 2002; Milieu Centraal, 2005).

The pivotal question remains why energy use of households keeps rising. On the one hand, macro-level factors contribute to this increase. These may be referred to as TEDIC factors: technological developments (e.g.

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energy-intensive appliances), economic growth (e.g. increase of household incomes), demographic factors (e.g. population growth), institutional factors (e.g. governmental policies) and cultural developments (e.g. emancipation, increasing mobility of women) (see Gatersleben & Vlek, 1998). In turn, these TEDIC factors shape individual (viz., micro-level) factors such as motivational factors (e.g. preferences, attitudes), abilities and opportunities (the MOA-model, see Ölander & Thøgerson, 1995). If the aim of interventions is to reduce negative environmental impact by changing households' consumption patterns, it is necessary to consider macro-level as well as micro-level variables (see also Gärling et al., 2002). Behavioral interventions may be aimed at voluntary behavior change, by targeting an individual's perceptions, preferences and abilities (i.e. MOA variables). Alternatively, interventions may be aimed at changing the context in which decisions are being made, for instance, through financial rewards, laws, or the provision of energy-efficient equipment (i.e. TEDIC factors). The latter strategy is aimed at changing the pay-off structure, so as to make energy-saving activities relatively more attractive. As this review will show, interventions within the realm of social and environmental psychology predominantly focus on voluntary behavior change, rather than changing contextual factors which may determine households' behavioral decisions.

Behaviors related to household energy conservation can be divided into two categories: efficiency and curtailment behaviors (Gardner & Stern, 2002). Efficiency behaviors are one-shot behaviors and entail the purchase of energy-efficient equipment, such as insulation. Curtailment behaviors involve repetitive efforts to reduce energy use, such as lowering thermostat settings. Studies reviewed in this paper were aimed at both efficiency and/or curtailment behaviors, with the latter seeming somewhat overrepresented. This is striking, because the energy-saving potential of efficiency behaviors is considered greater than that of curtailment behaviors (e.g. Gardner & Stern, 2002). For instance, households may save more energy by properly insulating their homes than by lowering thermostat settings. It should be noted however, that energy-efficient appliances do not necessarily result in a reduction of overall energy consumption when people use these appliances more often (the so-called rebound effect, see Berkhout, Muskens, & Veldhuijsen, 2000). Here, the importance of the interplay between macro-level (e.g. technological innovations) and micro-level factors (e.g. knowledge of efficient use of technological innovations) becomes apparent.

Various social and environmental psychological studies have embarked on issues related to household energy use. One line of research focuses on testing the effectiveness of intervention strategies aiming to change energy-related behaviors. Another line of research is theory driven and aims to identify underlying determinants of energy use, such as attitudes (e.g. Becker, Seligman, Fazio, & Darley, 1981) and socio-demographics (e.g. Black, Stern, & Elworth, 1985). In some studies, both the effectiveness of an intervention as well as (changes in) underlying determinants of energy use are monitored simultaneously (e.g. Geller, 1981; Staats, Wit, & Midden, 1996). The latter give additional insight into reasons why interventions were successful or not, and as such, they are a starting point for the further enhancement of an intervention's effectiveness.

The purpose of this paper is twofold. First, empirical studies on the effectiveness of interventions to promote household energy conservation are reviewed. The aim is to come to consistent findings with respect to the effectiveness of these interventions. It is examined which factors determine an intervention's success or failure. Interventions are more effective to the extent that they target determinants of energy use and energy savings (e.g. attitudes, knowledge). Second, based on the strengths and shortcomings of the research reviewed here, suggestions are given on how to improve our understanding and knowledge of effective intervention planning. In doing so, this review aims to complement and update previous reviews on energy conservation and other pro-environmental behaviors (e.g. Cook & Berrenberg, 1981; DeYoung, 1993; Dwyer, Leeming, Cobern, Porter, & Jackson, 1993; Geller, 2002; Schultz, Oskamp, & Mainieri, 1995; Stern, 1992; Winett & Kagel, 1984).

2. Method

2.1. Selection procedure

Various social and environmental psychological journals and databases (e.g. PSYCHLit, WebSPIRS) were consulted. Further, reference lists of articles were used to locate additional published material. This search resulted in a total of 38 peer-reviewed (i.e. quality guarantee) studies, dating from 1977 to 2004. These studies were mostly field experiments, using quasi-experimental designs. One single study was conducted in a laboratory setting.

In order to be selected for review, the study had to include a design allowing for effects to be measured either compared to a baseline (pretest/post-test design) or to a control group. Another important selection criterion was that the target group under study be households. The main reason for this is the differential effect an intervention may have depending on the target group. For instance, comparative feedback (i.e. feedback about the performance of others) has been shown to have positive effects on reducing energy use in the workplace (see Siero, Bakker, Dekker, & Van den Burg, 1996). As this review will indicate, the results are not as clear-cut for households (e.g. Van Houwelingen & Van Raaij, 1989).

The selected studies are classified according to the taxonomy for behavior change interventions as proposed by Geller et al. (1990) (see also Dwyer et al., 1993; Schultz et al., 1995), in which a distinction is made between antecedent and consequence strategies. Antecedent interventions are assumed to influence one or more determinants prior to the performance of environmentally significant behaviors. For instance, providing households with information about energy-saving options may result in energy savings, because people have acquired (more) knowledge. A consequence strategy is assumed to influence determinants *after* the occurrence of a pro-environmental behavior, by means of providing a consequence which is contingent on the outcome of the behavior. For instance, giving households feedback about their energy savings may encourage them to (further) reduce energy use, because their level of self-efficacy (i.e. perceived possibilities to conserve energy) has increased.

2.2. Evaluation criteria

To assess the effectiveness of interventions aimed at reducing energy use, the following criteria were considered. First, the extent to which interventions resulted in behavioral changes and/or reductions of energy use is reported. It is important to monitor both, because households may have adopted energy-saving behaviors without decreasing overall energy use. Second, an indication is given of the extent to which these changes can be attributed to the intervention(s), by comparing experimental groups with a control group not exposed to the intervention(s). Where sufficient quantitative information was reported, effect sizes were calculated. The effect size index used for this purpose was Cohen's d, which was estimated by dividing the between-groups difference in mean scores by the pooled within-group standard deviation (Hunter & Schmidt, 1990). The effect size was given a positive value when the experimental groups saved more energy than the control group, and a negative value when they used more energy. Effect sizes thus represent the number of standard deviation units by which the intervention group outperformed the control group on a certain outcome variable (e.g. gas savings, electricity savings). When means and standard deviations were not provided, effect sizes were calculated from other available statistical information (e.g. F-ratios, t-tests) according to tables and formulas proposed by Glass, McGraw, and Smith (1981), and Seifert (1991). Not infrequently however, the necessary statistical information was not reported, and consequently, effect sizes could not be calculated. Therefore, conducting a thorough meta-analysis was not deemed feasible. Third, it was examined why interventions were (in)effective, by means of reporting changes in underlying behavioral determinants. Our assumption is that interventions are more effective to the extent that they target and change important determinants of energy use. For example, an information campaign may not have been effective because no increase in knowledge occurred. Such conclusions can be drawn only when changes in behavioral determinants and in actual behavior are monitored simultaneously. Finally, it is reported whether the effects of the interventions were monitored over a longer period of time, in order to assess whether households persisted in behaving in an energy-efficient way, well after the intervention was discontinued.

In this paper, studies using antecedent interventions (commitment, goal setting, information, and modeling) will be discussed first, followed by studies using consequence interventions (feedback and rewards). Various studies examined the effect of a combination of antecedent and/or consequence strategies and these studies are grouped according to the intervention being varied across experimental conditions. In the text, main issues concerning the studies will be addressed. Additional information can be found in Table A1 (see Appendix), which lists all studies reviewed here. This table gives an overview of type of intervention(s), design of the study, total number of participating households, target behavior (and whether this involved curtailment behaviors, efficiency behaviors, or both), measurement of determinants, duration of the intervention, effectiveness of the intervention, effect sizes, and long-term effects.

3. Antecedent Interventions

In this section, studies are discussed using antecedent interventions to promote household energy conservation. As mentioned earlier, antecedent interventions influence one or more determinants prior to the performance of behavior. That is, interventions (e.g. information) are aimed at influencing underlying behavioral determinants (e.g. knowledge), which in turn are believed to influence behavior. The following interventions are considered antecedent interventions: commitment, goal setting, information, and modeling.

3.1. Commitment

A commitment is an oral or written pledge or promise to change behavior (e.g. to conserve energy). More often than not, this promise is linked to a specific goal, for instance, to reduce energy use by 5%. This promise can be a pledge to oneself, in which case it may activate a personal norm (viz., a moral obligation) to conserve energy. The promise can also be made public, for instance, by means of an announcement in the local newspaper. Then, social norms (viz., expectations of others) may play a role as determinants of conservation behavior.

Katzev and Johnson (1983) measured the effect of commitment on electricity consumption, by means of the so-called foot-in-the-door technique. The assumption behind this technique is that compliance to a first (smaller) request will result in compliance to a subsequent (bigger) request. In the first study, households either received a (small) request to fill out a questionnaire, a (bigger) request to sign a commitment to conserve energy by 10%, or both requests. The commitment was accompanied by information about energy conservation. Households who had received either request, or both, saved more energy compared to a control group. This effect did not emerge during the intervention, but during a follow-up period. In a subsequent study (Katzev & Johnson, 1984), two experimental groups were added: households who received a reward (depending on the amount of electricity saved), and households who received all interventions (questionnaire + commitment + information + reward). In contrast to the previous study, the effect occurred only during (the first week of) the intervention period: the commitment group and the combined treatment group showed the largest decline in electricity use. A relatively low number of respondents per condition may have reduced the statistical power of both designs.

Pallak and Cummings (1976) used commitment to promote gas and electricity conservation among households. Those who had signed a public commitment (i.e. publication in a leaflet) showed a lower rate of increase in both gas and electricity consumption than those in either the private commitment or the control group. This effect was maintained over a period of 6 months following discontinuation of the intervention.

3.2. Goal setting

Goal setting entails giving households a reference point, for instance to save 5% or 15% energy. A goal can be set by the experimenters, or by the households themselves. It is often used in combination with other interventions, such as feedback (to indicate how households are performing relative to the goal), or as part of a commitment to conserve a certain amount of energy. In this section, we discuss studies in which the unique contribution of goal setting could be established. For goal setting as part of other interventions, the reader is referred to the sections on commitment and feedback.

Becker (1978) gave households either a relatively difficult goal (20%) or a relatively easy goal (2%) to reduce electricity use. The goal was either combined with feedback (three times a week), or not. All households (including the control group) received information on which appliances used most electricity. Households who received a difficult goal and feedback conserved most (15.1%) and were the only group to significantly differ from the control group. This indicates that in order for a (difficult) goal to work, households need feedback on how they are performing in relation to the goal. An easy goal appeared not to be effective at all; 2% may have been perceived as not being worth the effort.

One of the few studies to take 'the field' into 'the lab' was conducted by McCalley and Midden (2002). They applied goal setting in combination with feedback to one specific energy-related behavior: doing the laundry. In a laboratory setting, a goal setting procedure was used, and immediate feedback was given about average amount of energy (kWh) used per washing trial, displayed in a simulated control panel of a washing machine. Participants who had been given a goal as well as feedback saved more energy per washing trial than participants who had only received feedback (without a goal). No significant difference emerged between participants who had been able to set a goal themselves and those with an assigned goal. Social value orientation (i.e. the extent to which one values outcomes for oneself or for others) was measured as well, and interestingly, there was a significant interaction between social value orientation and type of goal. For pro-self respondents, an assigned goal resulted in lower energy savings than a self-set goal, while for pro-social respondents the reverse was true.

3.3. Information

Information is a commonly used strategy to promote energy conservation behaviors. This may be general information about energy-related problems, or specific information about possible solutions, such as information about various energy-saving measures households can adopt. Providing information serves to increase households' awareness of energy problems and their knowledge about possibilities to reduce these problems. Information about energy conservation can be conveyed to households in several ways. In this section, we discuss workshops, mass media campaigns and tailored information.

3.3.1. Workshops

Geller (1981) measured the effectiveness of a workshop, in which information about energy-saving measures was given. In addition, each participant received a shower-flow restrictor and a booklet with information about energy conservation. The workshop led to higher levels of concern about the energy crisis, to an increase in knowledge about energy conservation, and stronger intentions to adopt energy-saving measures. Home-visits revealed no differences between attendees and nonattendees in the number of adopted energy-saving measures. So, although information did influence underlying determinants of energy use, it did not result in behavioral changes.

3.3.2. Mass media campaigns

Luyben (1982) evaluated the effectiveness of President Carter's televised plea to lower thermostat settings in view of a potential gas shortage. Three days after the appeal, randomly selected residents were surveyed either by telephone or a door-to-door interview. There appeared to be no difference in thermostat settings between those who had heard the plea and those who had not. Also, no difference in knowledge of the fact that lowering thermostat settings would help reduce energy use was found between those who had and those who had not heard the plea. Interestingly, self-reported thermostat settings appeared to be significantly lower than those observed by interviewers, pointing to a possible influence of social desirability.

Hutton and McNeill (1981) evaluated the Low Cost/No Cost energy conservation program of the US Department of Energy. A booklet of energy-saving tips and a shower flow control device was sent to 4.5 million households. In addition, a mass media campaign was launched. To evaluate its success, a telephone survey was conducted. Households who had received the booklet and the shower device reported implementing the energy-saving tips more often than households who had not. Overall, those who had installed the shower flow device reported applying significantly more tips than those who had not. It is not reported whether the intervention resulted in actual energy savings.

A study by Staats et al. (1996) evaluated a mass media campaign of the Dutch government, aimed at communicating the nature and causes of global warming, and possible ways of dealing with it. A pretest/post-test survey revealed a slight increase in knowledge, but levels of awareness of the problem remained unchanged. Willingness to behave pro-environmentally increased, but only among those who had already been behaving pro-environmentally before the campaign. Knowledge and problem awareness were not related to self-reported pro-environmental behaviors.

3.3.3. *Tailoring: home audits*

Tailored information is highly personalized and specific information. An advantage of this approach is that participants receive relevant information only, rather than getting an overload of general information, which may not always apply to their household situation. Tailoring has already gained its merits in other domains, such as health care (see Kreuter, Farrell, Olevitch, & Brennan, 1999). Examples of tailoring in the realm of energy conservation are energy audits, i.e. a home visit by an auditor who gives households a range of energy-saving options (efficiency and curtailment behaviors) based on their current situation. For instance, they may advise a household to apply insulation and lower thermostat settings.

Several studies investigated the effect of home energy audits. A study by Winett, Love, and Kidd (1982–1983) showed that households who had received an energy audit (providing information on heating and air conditioning) used 21% less electricity, compared to a control group.

Hirst and Grady (1982–1983) compared gas consumption of households who had received home audits to those who had not. One year following the audit, households had saved 1–2% on gas use, compared to the control group; 2 years following the audit, this amounted to 4%. In addition, households in the audited group reported applying more energy-saving measures than the control group. Contrary to what was expected, a more positive attitude towards gas conservation was associated with higher gas use. The authors draw cautious conclusions, expressing doubts about data quality.

Another study examined whether energy auditors trained to use persuasion principles (e.g. use of vivid, personalized information) would be more successful in encouraging households to adopt energy-saving measures than auditors without such training (Gonzales, Aronson, & Costanzo, 1988). Households in the trained-auditor group reported a significantly greater likelihood of making the recommended changes than households in the other group. After making these changes, homeowners could apply for a rebate. The number of applications served as a behavioral measure for evaluating the audit's success. Significantly more homeowners from the trained auditor condition applied for a financial rebate. However, no difference in actual energy use was found.

McDougall, Claxton, and Ritchie (1982–1983) evaluated the Canadian ENERSAVE program. Households who participated in the program completed a questionnaire about current behaviors related to energy use (e.g. amount of insulation, thermostat settings). One group of participants received tailored information after sending in the questionnaire; the other group of participants did not. Two years later, participants were contacted again, and no differences were found in reported energy-saving actions, or in actual energy use between those who had received tailored information and those who had not. A possible explanation is the relatively long time that elapsed between implementation of the intervention and its effect measurement.

Recently, McMakin, Malone, and Lundgren (2002) applied tailoring to energy conservation among households living at two US military installations. The tailored information was based on focus group interviews conducted prior to the intervention. Information about energy conservation in the first installation (in the state of Washington) targeted heating-related energy use and the second (located in Arizona) targeted cooling-related energy use. Results were mixed: households in Washington saved 10% on their gas and electricity use, and households in Arizona used 2% more electricity, compared to baseline levels.

3.4. *Modeling*

Modeling, based on Bandura's learning theory (1977), entails providing examples of recommended behaviors. It is assumed that these examples will be followed when they are understandable, relevant, meaningful and rewarding (in terms of positive results) to people. Winett, Leckliter, Chinn, Stahl, and Love (1985) used modeling by means of cable TV. The program was tailored in the sense that it was targeted at middle-class homeowners and it showed various energy-saving measures. Viewers also received an information booklet containing cartoons depicting energy-saving measures. The TV modeling group significantly reduced energy use by 10%, compared to a control group. Before and after measures revealed a significant increase in knowledge for the experimental group, but not for the control group. A follow-up study one year later showed that the energy savings were not maintained.

4. Antecedent interventions: conclusions

Commitment may be a successful strategy for reducing household energy use, especially in view of the long-term effects found in several studies (Katzev & Johnson, 1983; Pallak & Cummings, 1976). However, Katzev and Johnson's second study (1984) only found short-term effects of commitment. Studies on goal setting (Becker, 1978; McCalley & Midden, 2002) showed that combining goal setting with feedback was more effective than goal setting alone. Information has also proven to be more effective when used in combination with other interventions (e.g. Van Houwelingen & Van Raaij, 1989). The effects of information seem to depend largely on its specificity. Mass media campaigns tend to result in an increase in attitudes or knowledge (e.g. Staats et al., 1996), but there is no clear evidence that this results in reductions of energy use. It may well be that a more personalized approach such as tailoring is more effective. Home energy audits, using tailored energy advice, had positive effects on household energy use (Winett et al., 1982–1983) and on the extent to which efficiency actions were taken (Gonzales et al., 1988). Also, tailored information was successful among households in a military installation (McMakin et al., 2002), but McDougall et al. (1982–1983) failed to find any reductions in energy use as a result of tailoring. Finally, modeling (Winett et al., 1985) resulted in a knowledge increase, and was also effective in reducing energy use. Strikingly, a number of studies included relatively low numbers of households per experimental condition, which may have been a cause for not finding any statistically significant effects. Also, it has been shown that combinations of interventions are especially effective in reducing energy use. However, studies often employ designs without including experimental conditions in which the single interventions were used, in which case it is difficult to establish any additional effects of the combination over and above the interventions separately.

5. Consequence interventions

Consequence strategies are based on the assumption that the presence of positive or negative consequences will influence behavior. Pro-environmental behavior will become a more attractive alternative when positive consequences are attached to it (e.g. by providing a monetary incentive), and environmentally unsound behavior will become less attractive when negative consequences are attached to it. Feedback and rewards will be discussed in this section.

5.1. Feedback

Feedback is often applied to promote energy conservation. Feedback consists of giving households information about their energy consumption, or energy savings. It can influence behavior, because households can associate certain outcomes (e.g. energy savings) with their behavior. Ideally, feedback is given immediately after the behavior occurs (Geller, 2002). First, we discuss studies focusing on the differential effect of feedback frequency, followed by studies systematically varying feedback content.

5.1.1. Continuous feedback

McClelland and Cook (1979–1980) gave households continuous feedback over a period of 11 months about monetary costs of electricity use by means of a monitor displaying electricity use in cents per hour. On average, households who had a monitor installed in their homes used 12% less electricity than a control group.

In a similar vein, Hutton, Mauser, Filiatrault, and Ahtola (1986) tested whether continuous cost-related feedback by means of the so-called Energy Cost Indicator (ECI) would be effective in reducing gas and electricity use. They also provided participants with information about energy conservation. The study was conducted in two Canadian and one American city. In the Canadian cities, behavioral changes were observed: households who had either received information only, or information combined with feedback used 4–5% less energy than a control group. However, no changes in knowledge were observed. In the American city however, an increase in knowledge occurred, but no behavioral effect was found. The authors attribute this to the possibility that knowledge of energy issues was already higher in Canada than in the US (i.e. ceiling effect).

Another study using a similar Indicator was done by Van Houwelingen and Van Raaij (1989). They investigated the differential effect of continuous versus monthly feedback on gas consumption by means of a feedback monitor displaying daily gas use as well as daily target consumption (based on annual gas use), the latter serving as conservation goal. All households received information about energy conservation. It appeared that households who had received continuous feedback saved more gas (12.3%) than those who had received monthly feedback (7.7%), those who had been taught to read their gas meter (5.1%) and those who had only received information (4.3%). No significant changes in gas use were observed in a control group. This study found that low users of gas actually increased gas use during the intervention. One year after termination of the intervention, gas use had increased for all groups, compared to baseline levels.

Sexton, Brown, Johnson, and Konakayama (1987) gave continuous feedback about the difference between monetary costs of electricity used in on- and off-peak periods (the latter having a cheaper rate). Feedback did result in a shift in consumption to off-peak periods, which was largest for those households who had been given a higher price difference. However, total electricity consumption did not decrease. In this case, the feedback may have also served as a financial incentive (viz., reward).

5.1.2. Daily feedback

Bittle, Valesano, and Thaler (1979) assigned households into either a daily feedback group or a control group. The feedback group saved an average of 4% on their electricity use (compared to baseline consumption), and also saved more than the control group. Then, the treatment was reversed. Households initially part of the feedback group (now no longer receiving feedback) continued saving more electricity than the control group (now receiving feedback). This is probably due to a carry-over effect: new habits may have formed; persisting even after feedback was discontinued.

Bittle, Valesano, and Thaler (1979–1980) explored the differential effect of feedback content. All households received daily feedback, but a distinction was made between feedback about previous day's electricity use and cumulative feedback (electricity use since first of the month). Another distinction was made between feedback in terms of kWh and in terms of cost. High consumers of electricity showed a lower rate of increase in electricity use, with cumulative feedback being somewhat more effective than feedback about daily use. For medium and low consumers however, feedback appeared to have the opposite effect and resulted in an increase of electricity use.

Katzev, Cooper, and Fisher (1980–1981) either gave households daily feedback about electricity use (kWh, cost and compared to other households), feedback every third day (kWh, cost, and compared to others), or noncontingent (viz., regardless of whether households had actually saved electricity or not) feedback (kWh and cost). No significant group differences in electricity use were found, possibly due to a low number of respondents in each experimental group.

Feedback and self-monitoring were compared in a study on electricity use (Winett, Neale, & Grier, 1979). Households were given information about how to conserve and they were asked to choose an energy conservation goal. Results show that households who had received daily feedback used 13% less electricity, and households who were taught to read their outdoor meters (self-monitoring) used 7% less electricity than did a control group. This effect was still present during a follow-up measurement.

Seligman and Darley (1977) found feedback to have a positive effect on electricity conservation. All participating households were told that air conditioners were the largest users of electricity in homes. Half of them received feedback about electricity savings (four times a week during one month), while the other half did not receive any feedback. Households in the feedback group used 10.5% less electricity than the control group did. There was no follow-up measurement to determine whether the effect was maintained.

5.1.3. Weekly and monthly feedback

A recent study by Völlink and Meertens (1999) used a combination of weekly feedback, goal setting (households had a choice between 5%, 10%, or 15% energy savings), and information (energy-saving tips) through text TV. Households who were subject to the combination of interventions saved more energy than the control group did. However, since participants were living in energy-efficient homes, the results cannot easily be generalized to the general population.

Hayes and Cone (1981) examined the effect of monthly feedback on electricity use, both in terms of kWh as well as in terms of money. Households who had received feedback reduced electricity use by 4.7%, while households in the control group increased electricity use by 2.3%. After the feedback was withdrawn, electricity use was monitored over a period of 2 months, and during this period, the pattern was reversed: households in the experimental group used 11.3% more, while households in the control group saved 0.3% compared to baseline levels.

A study by Heberlein and Warriner (1983) focused on the price difference between on- and off-peak periods (the latter having a cheaper rate). Households received monthly feedback (through their electricity bill) about the amount of kWh they had used in on- and off-peak periods. Knowledge of price ratio and behavioral commitment to shift consumption from on-peak to off-peak periods were measured. Larger price differences resulted in larger shifts to off-peak periods. Regression analysis revealed knowledge and behavioral commitment to have stronger effects on this shift than price had. It was not reported whether feedback about price ratio led to reductions in electricity use.

Kantola, Syme, and Campbell (1984) used a combination of feedback and information among above average consumers of electricity. They used feedback to evoke cognitive dissonance by informing households that even though they had previously indicated feeling a duty to conserve energy, they were high consumers of electricity. All participants received energy-saving tips. The first group received cognitive dissonance feedback, the second group received feedback that they were high consumers of electricity (without inducing cognitive dissonance), the third group only received energy-saving tips. During the first 2 weeks of the intervention period, the cognitive dissonance group saved significantly more electricity than the other groups did. For the second 2 weeks, the dissonance group differed from the control group only.

5.1.4. Comparative feedback

Feedback about individual performance relative to performance of others may be helpful in reducing household energy use as well. By giving comparative feedback, a feeling of competition, social comparison, or social pressure may be evoked, which may be especially effective when important or relevant others are used as a reference group.

Midden, Meter, Weenig, and Zieverink (1983) tested the effectiveness of comparative feedback, individual feedback, monetary rewards and information. The comparative feedback consisted of a comparison with consumption levels of households in similar settings. Only marginally significant differences emerged between the groups. For electricity use, households who had either received comparative feedback, individual feedback or rewards tended to save more than the control group did. For gas use, households who had received either individual feedback or rewards tended to save most. Overall, comparative feedback was not more effective than individual feedback, and providing households with information alone was not effective at all.

In a recent study, a distinction was made between comparative feedback (i.e. own savings compared to other participants), individual feedback, feedback about financial costs, and feedback about environmental costs (Brandon & Lewis, 1999). Also, one group of households received feedback on a leaflet, while another received computerized feedback. The difference in energy savings between all feedback groups combined and the control group was only marginally significant. Computerized feedback appeared to be relatively successful, the number of conservers in this group being significantly higher than the number of nonconservers. High and medium consumers saved energy (3.7% and 2.5%, respectively) whereas low consumers increased energy use (by 10.7%), which corroborates a similar finding by Bittle et al. (1979–1980). Environmental attitudes and beliefs were marginally significant predictors of energy savings. The authors indicate that a low number of households per condition and large within-group variances may have reduced the statistical power of the design.

Comparative feedback was also part of the so-called EcoTeam Program (ETP). EcoTeams are small groups (e.g. neighbors, friends, family) who come together once every month to exchange information about energy-saving options. They also receive feedback about own energy savings, and savings of other EcoTeams. Staats, Harland, and Wilke (2004) evaluated the ETP in the Netherlands, targeting various behaviors related not only to gas and electricity use, but also to water use, transportation, food consumption and waste management. A comparison group was used for a subset of eight energy-related behaviors. Repeated measures analysis revealed that ETP participants increased the frequency of pro-environmental behaviors over time, whereas the comparison group did not. After the program, ETP households had saved 20.5% on gas use, 4.6% on electricity use, 2.8% on water use, and had reduced their waste by 28.5%. Two years later, these savings were 16.9% for gas use, 7.6% for electricity use, 6.7% for water use, and 32.1% for waste reduction. ETP seems to be a promising intervention in that it proved to be successful in reducing energy use in several domains, both shortly after the program and during a follow-up two years later. Since a combination of interventions was used, it is difficult to attribute its success to comparative feedback. Also, respondents in this study presumably were highly motivated participants, making it difficult to generalize its results.

5.2. Rewards

Monetary rewards may serve as an extrinsic motivator to conserve energy. Rewards can either be contingent on the amount of energy saved, or a fixed amount (e.g. when a certain percentage is attained).

Hayes and Cone (1977) tested the effect of rewards, feedback and information on electricity use. The implementation of the interventions was done sequentially, in a multiple baseline design. All participating households reduced electricity consumption. However, based on a sample size of four and without reporting any statistical tests, these results cannot be generalized.

Winett, Kagel, Battalio, and Winkler (1978) studied the effect of high versus low monetary rewards in combination with feedback and information. During the first four weeks of the intervention, households in both high and low reward groups saved more energy than the other groups. During the second part of the intervention period, households who initially had only received information were now given a high reward, resulting in savings of 7.6%. Over a period of eight weeks, households who had received a high reward, feedback and information reduced electricity use by about 12%. It is not clear whether this effect was maintained after discontinuation of the rewards.

In a study focusing on households in master-metered apartments (i.e. who do not have own gas meters), contests were held with a reward for the apartment block able to save most (McClelland & Cook, 1980). Contending groups received weekly feedback on gas savings of the own as well as the other groups, and information on how to save energy. The contest groups used 6.6% less electricity than a control group of master-metered apartments. However, the savings decreased as the treatment period progressed, suggesting a short-term effect of rewards.

Rewards were also used in two other studies conducted with master-metered apartments (Slavin, Wodanski, & Blackburn, 1981). The first study investigated the combined effect of information, prompts (reminders), bi-weekly feedback (about the performance of the entire group) and rewards (100% of the value of electricity savings). All participants received the same combination of interventions. The intervention lasted 14 weeks for group 1 (savings of 11.2%), 12 weeks for group 2 (1.7%) and 8 weeks for group 3 (4%), and resulted in average savings of 6.2% relative to baseline. The effects appeared to be strongest immediately following implementation of the intervention. Their second study was set up along the same lines (Slavin et al., 1981, Study 2). Instead of receiving the full amount, participants now received 50% of the monetary value of electricity savings, and a bonus amount was given if total group savings exceeded 10%. The combination of interventions resulted in electricity savings of 9.5% (group 1), 4.7% (group 2), and 8.3% (group 3), with an average of 6.9%. In contrast to study 1, the effects did not decline during the treatment period, which may be attributed to the extra bonus. Due to the design of both studies, it is not possible to differentiate between the effects of the various components of the intervention.

Pitts and Wittenbach (1981) evaluated the effect of tax credits on consumers' decisions to insulate their homes. The credit consisted of a deduction from total income taxes, which was given after households had installed insulation. A telephone survey, conducted 2 years after the tax credit had come into effect, revealed that the credit had had no effect on the decision whether or not to install insulation.

6. Consequence interventions: conclusions

Feedback appears to be an effective strategy for reducing household energy use in most studies reviewed here (e.g. Seligman & Darley, 1977), although some exceptions exist (e.g. Katzev et al., 1980–1981). Results of studies using feedback seem to suggest that the more frequent the feedback is given, the more effective it is. Positive effects have for instance been found for continuous feedback (e.g. McClelland & Cook, 1979–1980). Three studies found differential effects for high and low consumers of energy, the latter group increasing their energy use as a result of feedback (Brandon & Lewis, 1999; Bittle et al., 1979–1980; Van Houwelingen & Van Raaij, 1989). Kantola et al. (1984) showed that high frequency is not necessarily the key to success: by giving feedback evoking cognitive dissonance one single time, households significantly reduced energy use. It is not clear whether it makes a difference to give feedback in terms of monetary rather than environmental costs, since studies investigating this difference did not find any (e.g. Brandon & Lewis, 1999; Bittle et al., 1979–1980). Studies using comparative feedback (e.g. Brandon & Lewis, 1999; Midden et al., 1989) did not find it to be more effective than individual feedback. Combining comparative feedback with rewards in a contest setting proved to be successful (McClelland & Cook, 1979–1980).

EcoTeams, who receive both individual and comparative feedback, were successful in reducing energy use, also in the long run. Combining feedback with goal setting resulted in reductions in energy consumption (McCalley & Midden, 2002), especially when combined with a difficult goal (Becker, 1978). Studies who examined the effect of giving feedback about the price difference between on- and off-peak hours found this to result in shifts in consumption to off-peak hours, but no difference in overall consumption was found or reported (Heberlein & Warriner, 1983; Sexton et al., 1987).

Overall, rewards seem to have a positive effect on energy savings: all studies reviewed here report significant differences between households who had received a reward and those who had not (e.g. Winett et al., 1978). Results of several studies (McClelland & Cook, 1980; Slavin et al., 1981) do however suggest that the effect of rewards is rather short-lived. Pitts and Wittenbach (1981) found that governmental influence in the form of tax credits was not a decisive factor in consumers' decisions to buy and install in-home insulation. Several studies may have failed to find any statistically significant effects due to a relatively low number of households per experimental condition and/or large within-group variance in energy use (e.g. Brandon & Lewis, 1999). Also, in some cases, it is difficult to make generalizations based on the results, for samples consisted of highly motivated participants (e.g. Staats et al., 2004). Another issue concerns confounding of effects: due to the use of combinations of interventions, it is difficult to establish the contribution of each intervention separately.

7. Discussion

Interventions to promote energy conservation among households have been employed with varying degrees of success. The antecedent interventions commitment and goal setting appeared successful in bringing about changes in energy use, especially when used in combination with other interventions (e.g. Becker, 1978). Generally, information alone is not a very effective strategy (e.g. Van Houwelingen & Van Raaij, 1989). Information about energy problems as conveyed by mass media campaigns tends to result in increases of knowledge and of (self-reported) conservation behaviors, but little is known about the effects on actual energy use (e.g. Staats et al., 1996). However, energy savings were achieved by giving households tailored information through home energy audits (e.g. Winett et al., 1982–1983).

As for consequence interventions, rewards are effective, but there is some indication of this positive effect disappearing as soon as the intervention is discontinued (see also Dwyer et al., 1993; Geller, 2002). Providing households with feedback, and especially frequent feedback, has proven to be a successful intervention for reducing energy consumption (e.g. Seligman & Darley, 1981). However, exceptions exist (e.g. Katzev et al., 1980–1981). Some studies found a differential effect for high and low consumers of energy, the former reducing energy use and the latter increasing energy use as a result of feedback (e.g. Bittle et al., 1979–1980). This is an important finding from a policy perspective, in the sense that policies aiming to reduce energy use may especially want to target high users of energy, because of a higher energy-saving potential.

The studies discussed here reveal that underlying determinants of energy use and energy-related behaviors have hardly been examined. In some cases, determinants of energy use or energy savings were measured, and it appeared that attitude and knowledge are generally positively related to energy savings (e.g. Brandon & Lewis, 1999; Heberlein & Warriner, 1983). Studies using before and after measurements have found an increase in knowledge levels after mass media campaigns (e.g. Staats et al., 1989), and workshops about energy conservation (Geller, 1981), but this did not necessarily result in behavioral changes or reductions in energy use. Winett et al. (1985) found modeling to result in significant energy savings and higher knowledge levels. Another study (Hutton et al., 1986) found a behavioral effect but no learning effect in one sample of participants, whereas in the other sample a learning effect but no behavioral effect was found.

A number of critical remarks can be made with respect to the intervention studies discussed here. The first issue concerns the fact that in some studies, the exact content of the intervention was not clearly specified. For instance, in some cases it is unclear whether information was provided about energy problems, about energy-saving measures, or both. Also, authors did not always specify which behaviors were targeted by the intervention (e.g. efficiency or curtailment behaviors). These specifications can be a decisive factor in evaluating an intervention's (in)effectiveness. In addition, interventions are not always explicitly mentioned. Main conclusions appear to be focused on the effectiveness of one intervention (e.g. feedback), but when reading the study design, other interventions (e.g. information) appear to have been used as well. Many studies have shown that a combination of strategies is generally more effective than applying one single strategy. However, confounding of effects makes it more difficult to determine which strategies actually contributed to the overall effect. More systematic research on the effectiveness of interventions under various circumstances would be advisable in this respect. This may well in part be done in experimental (laboratory) studies.

The second type of problems emerging from this review concerns methodological issues. Very small sample sizes, especially in conjunction with large within-group variances (in energy use) may have reduced the statistical power of designs and consequently, these studies may have failed to find any statistically significant effects. Moreover, households who participate in this type of studies tend to be highly motivated, tend to have higher than average incomes, and higher than average education levels, making generalizations based on these studies rather difficult. To illustrate, a study using a sample of four households claims to have established "unequivocally the independent effectiveness of payments" and to have demonstrated "the relative superiority of such a procedure over feedback and information" (Hayes & Cone, 1977, p. 433), without performing any kind of statistical test to substantiate this assertion. It is hardly warranted to generalize results based on samples sizes this small. Interestingly, this study has been cited in other articles as support for the effectiveness of rewards.

The third type of problems is related to the size of the effects found in the studies. First, effect sizes were not very high: Cohen's d was found to range from −0.07 to 1.41. Most studies did not report sufficient statistical information needed to calculate effect sizes (viz., means and standard deviations for experimental and control groups). It would be advisable for authors to provide these data so as to enable a thorough meta-analysis. More insight into effect sizes may also serve as valuable input for policies aiming to reduce household energy use. Second, different indicators are used to test the effectiveness of interventions. A number of studies report an effect of the intervention based on changes in self-reported energy-related behaviors. It is important to examine actual energy use as well, as behavioral changes do not necessarily result in energy savings. Besides, it may well be that self-reported behaviors were influenced by social desirability. For instance, Luyben (1982) found self-reported thermostat settings to be significantly lower than those observed by interviewers. However, Warriner, McDougall and Claxton (1984) compared observed energy-related behaviors with self-reported measures and found no significant differences between them. Assuming that self-reported behaviors do reflect reality, it still does not become clear whether the intervention had any impact on actual energy use (e.g. a so-called rebound effect may have occurred, see Berkhout et al., 2000). Households may have spent the money they initially saved by reducing energy use on energy-intensive products, thereby increasing overall energy use. Or, reductions in energy-related behaviors may have occurred, which were not monitored because they were not targeted by the intervention (spill-over effect). In addition, few studies report on the actual impact of energy savings. To illustrate, a reduction of 10% based on a total energy use of 1000 MJ is not the same as a reduction of 10% based on a total energy use of 10,000 MJ. This way, it does not become clear to what extent changes in behavior resulted in energy reductions.

Lastly, as mentioned elsewhere (see DeYoung, 1993; Dwyer et al., 1993), relatively little is known about the long-term effects of interventions. A majority of the studies did not monitor the effects of the interventions over longer periods of time. Consequently, it is not clear whether behavioral changes were maintained and whether new (energy-saving) habits were formed, or whether energy use returned to baseline levels. When a follow-up was included, often it appeared that the positive effects of the intervention were not maintained. There are exceptions to this, with some studies (Pallak & Cummings, 1976; Staats et al., 2004) reporting promising long-term effects.

8. Recommendations

Many environmental problems, such as energy use, are related to human behavior and, consequently, may be reduced through behavioral changes. Comparing previous reviews on interventions aimed at changing energy-related behaviors (e.g. Dwyer et al., 1993; Schultz et al., 1995) to the current one reveals similarities and differences. These previous reviews had already pointed out issues in order to improve intervention studies, such as the inclusion of long-term measurements and the use of study designs precluding a confounding of effects when using multiple interventions. Studies that have been published since then have provided additional insight into effective intervention planning by addressing these issues of concern. A study by Staats et al. (2004) examined and found long-term effects of interventions on both energy use and the adoption of energy-saving behaviors. Laboratory research has extended our knowledge of the separate and combined effect of interventions (McCalley & Midden, 2002). In addition, new methods of approaching households have been used, such as text TV (Völlink & Meertens, 1999) and computerized feedback (Brandon & Lewis, 1999), both showing promising effects in terms of energy reductions. Taken together, these new studies have added to our understanding of how to encourage household energy conservation.

The present review also comes to different conclusions. As opposed to Dwyer et al.'s (1993) recommendation to use antecedent interventions only, we found that single antecedent interventions are not very effective. Rather, we found an antecedent intervention's effectiveness (e.g. goal setting) to increase when combined with consequence strategies (e.g. feedback, see Becker, 1978; McCalley & Midden, 2002; Van Houwelingen & Van Raaij, 1989). In this concluding section, several additional guidelines are proposed to help researchers and policy makers effectively design, implement and evaluate intervention programs to reduce household energy use in the future.

An important first step in designing and implementing interventions aimed at reducing energy use among households is a thorough problem diagnosis (Geller, 2002). First, by identifying behaviors that significantly contribute to environmental problems, and second, by examining factors that make sustainable behavior patterns (un)attractive, such as motivational factors (e.g. attitudes), opportunities, and perceived abilities. It is important that interventions address and change possible barriers to behavioral change (see also Gardner & Stern, 2002). Therefore, a problem diagnosis is necessary in examining which behaviors and which behavioral determinants should be targeted by the intervention. For example, financial incentives will be effective only when people in fact take prices into consideration when making choices and educational campaigns may especially be advisable when people are unaware of energy use and environmental problems associated with their behavior. In terms of reducing environmental impact, it is important to identify target behaviors that have a relatively large energy-saving potential. By keeping environmental goals in mind, researchers and intervention planners can focus on behaviors and target groups that significantly influence environmental qualities.

The following recommendation is related to the observation that interventions studies typically have a monodisciplinary focus. Intervention studies from a psychological perspective tend to focus predominantly on changing (individual-level) MOA-variables (e.g. attitudes, abilities). It is equally important to target macro-level factors contributing to household energy use, such as demographic or societal developments (e.g. TEDIC factors), which shape the physical infrastructure and technical apparatus that condition behavioral choices and energy use associated with these choices. It is therefore important to consider household energy conservation from a multidisciplinary perspective. For instance, sociologists can provide more insight into macro-level factors that shape household energy use. Also, input from environmental scientists can be of valuable importance to further improve intervention studies. The environmental sciences can help translate energy-related behaviors of households into their environmental impact, e.g. in terms of CO_2 emissions, and help select high-impact behaviors.

Finally, evaluations of an intervention's effectiveness should be focused on (changes in) behavioral determinants as well as (changes in) energy-related behaviors. Most studies reveal only to what extent interventions have been successful, without providing insight into the reasons why. For instance, failure of a mass media campaign to change behavior may well be attributable to the fact that target groups were already familiar with the information provided. In other words, the effectiveness of interventions and possible determinants of behavior should be examined simultaneously. A thorough monitoring of determinants of energy use and energy savings may increases our understanding of the success or failure of intervention programs. The guidelines proposed here may help researchers and policy makers design and implement effective intervention programs to encourage a more sustainable behavior pattern.

Appendix

Table A1
Overview of intervention studies on household energy conservation (including author(s), type of intervention, design and number of groups, total sample size, target behavior, behavioral determinants, duration, effects during the intervention, effect sizes and long-term effect)

Author(s)	Intervention(s)	Design	N	Target behavior[a]	Behavioral determinants[b]	Duration	Effect during intervention	Effect size	Long-term effect
Becker (1978)	(1) Feedback (2) Goal setting (3) Information	(1) 20% goal, feedback 3 × per week (2) 2% goal, feedback 3 × per week (3) 20% goal (4) 2% goal (5) Control	100	Electricity use (C)	Not measured	1 month	(1) 20%-feedback: 15.1% (2) 2%-feedback: 5.7% (3) 20%-no-feedback: 4.5% (4) 2%-no-feedback: −0.6%	(1) $d = 0.97$ (2) $d = 0.36$ (3) $d = 0.09$ (4) $d = -0.07$	Not measured
Bittle et al. (1979)	(1) Feedback	(1) Daily feedback (costs) (2) Control	30	Electricity use	Not measured	42 days	Feedback group reduced electricity use by 4%, compared to baseline, and conserved more than the control group.		*24-day reversal* Experimental group no longer received feedback; still used less electricity than control group, now receiving feedback.
Bittle et al. (1979–1980)	(1) Feedback	(1) Cumulative feedback (kWh) (2) Cumulative feedback (costs) (3) Daily use feedback (kWh) (4) Daily use feedback (costs)	353	Electricity use	Not measured	35 days	For high consumers of electricity, all four types of feedback resulted in a lower rate of increase, but for medium and low consumers of electricity it resulted in an increase in consumption.		Not measured
Brandon and Lewis (1999)	(1) Feedback	(1) Comparative feedback (2) Individual feedback (3) Cost feedback (4) Environment feedback (5) Leaflet feedback (6) Computer feedback (7) Control	120	Gas and electricity use	*Of savings* Attitudes (+) *Of energy use* Age (+) Household Size (+) Income (+)	2 months	(1) Comparative: 4.6% (2) Individual: −1.5% (3) Cost: 4.8% (4) Environment: −4.5% (5) Leaflet: 0.4% (6) Computerized: 4.3% (7) Control: −7.9%		Not measured
							Marginally significant difference between feedback groups combined and control.	Feedback vs. no feedback: $d = 0.31$	
Geller (1981)	(1) Information (workshop)	(1) Information (2) Control	117	Electricity, gas and water use (C, E)	*Pre/post* Attitudes (+) Knowledge (+) Intention (+)	3 hours	The workshop resulted in an increase in levels of determinants.		*6–12 weeks after workshop* No behavioral effect was found.

Gonzales et al. (1988)	(1) Information (audits) (2) Rebate	(1) Information (trained auditors), rebate (2) Information (nontrained auditors), rebate	408	Gas and electricity use (C, E)	Not measured		*1–2 weeks after audit* Households in trained-audit group reported a greater likelihood of following through on recommendations.		*4 months after audit* Households in trained-audit group had followed recommendations more often, but no difference in energy consumption.
Hayes and Cone (1977)	(1) Rewards (2) Feedback (3) Information	Multiple baseline design: interventions sequentially implemented.	4	Electricity use (C)	Not measured	91 days	All households reduced electricity consumption, compared to baseline.		Not measured
Hayes and Cone (1981)	(1) Feedback	(1) Monthly feedback (2) Control	40	Electricity use	Not measured	4 months	Feedback group: 4.7% Control group: −2.3%		*2-month follow-up* Feedback: −11.3% Control: 0.3%
Heberlein and Warriner (1983)	(1) Feedback	(1) Monthly feedback (price ratio) (2) Control	600	Electricity use	*Of on-peak electricity use* Knowledge (−) Behavioral commitment (−)	3 years	Larger price differences between on-peak and off-peak periods resulted in larger reductions of on-peak electricity use.		Not measured
Hirst and Grady (1982–1983)	(1) Information (audits)	(1) Information (2) Control	850	Gas use (C, E)	*Of gas use* Income (+) Attitudes (+)		One year after home visits: gas savings of 2%, compared to control group.	$d = 0.10$	*2 years after audit* Gas savings of 4%, relative to control.
Hutton and McNeill (1981)	(1) Information	(1) Information (media campaign), shower flow device (2) Control	1811	Gas, electricity and water use (C, E)	Not measured	1 month	Experimental group adopted more energy saving tips than the control group. No data reported on actual energy savings.		Not measured
Hutton et al. (1986)	(1) Feedback (2) Information	(1) Feedback, information (2) Information (3) Control	300	Gas and electricity use	*Pre/post* Knowledge (+) (only in US city)		Feedback + information group and information only group conserved more energy than controls (but only in Canadian cities).		Not reported
Kantola et al. (1984)	(1) Feedback (2) Information	(1) Dissonance feedback, information (2) Feedback, information (3) Information (4) Control	118	Electricity use (C)	*Electricity use* Personal duty to save (n.s.) Importance of energy conservation (n.s.)	4 weeks	The cognitive dissonance group saved significantly more electricity than the other groups. For the second two weeks, this group only differed from control.		Not measured
Katzev et al. (1980–1981)	(1) Feedback	(1) Daily feedback (2) Feedback every 3rd day (3) Non-contingent feedback (4) Control	44	Electricity use	Not measured	2 weeks	No significant differences between experimental groups and control group.		*2-week follow-up* No significant differences.

Table A1 (*continued*)

Author(s)	Intervention(s)	Design	*N*	Target behavior[a]	Behavioral determinants[b]	Duration	Effect during intervention	Effect size	Long-term effect
Katzev and Johnson (1983)	(1) Commitment (2) Information	(1) Request (questionnaire) (2) Request (commitment) (3) Both requests (4) Control	66	Electricity use	Not measured	4 weeks	No significant differences between groups.		*12-week follow-up* Experimental groups conserved more electricity than control group.
Katzev and Johnson (1984)	(1) Commitment (2) Incentive (3) Information	(1) Request (questionnaire) (2) Request (commitment) (3) Both requests (4) Incentive (5) Both requests, incentive (6) Control	90	Electricity use	Not measured	2 weeks	The commitment only and the group receiving all interventions conserved more electricity than the other groups (but only in first week).		*2 months follow-up* No significant differences between the groups.
Luyben (1982)	(1) Information (televised plea)	(1) Plea (2) No plea	210	Lower thermostat settings to 65°F (C)	*Post-test only* No difference in knowledge between groups.		*Three days following plea* No difference in thermostat settings between those who had and had not heard the plea.		Not measured
McCalley and Midden (2002)	(1) Feedback (2) Goal setting	(1) Feedback (2) Feedback, self-set goal (3) Feedback, assigned goal (4) Control	100	Doing laundry (load and temp. setting) (C)	Pro-self respondents saved more energy with self-set goal and less with assigned goal	20 washing trials	Feedback combined with goal setting was more effective than feedback alone. Participants with a self-set goal saved 21.9%, those with an assigned goal saved 19.5%.		Not measured
McClelland and Cook (1979–1980)	(1) Feedback	(1) Continuous feedback (2) Control	101	Electricity use (C)	Not measured	11 months	Continuous feedback resulted in average savings of 12%, compared to control.		Not measured
McClelland and Cook (1980)	(1) Reward (2) Feedback (3) Information	(1) Reward, feedback, information (2) Control	500	Gas use	Not measured	12 weeks	On average, 6.6% gas was saved by the contest groups.		Not measured
McDougall et al. (1982–1983)	(1) Information (tailoring)	(1) Information (2) No information (3) Control	1451	Various behaviors related to heating (C & E)	Not measured		Not reported		*After 2 years* No difference in number of energy saving activities.

McMakin et al. (2002), *Study* 1	(1) Information (tailoring)	(1) Information	1231	Gas and electricity use (related to heating)	Not measured	1 year	Households saved 10% energy compared to baseline.		Not measured
McMakin et al. (2002), *Study* 2	(1) Information (tailoring)	(1) Information	175	Electricity use (related to cooling)	Not measured	4 months	Households used 2% more electricity, compared to baseline.		Not measured
Midden et al. (1983)	(1) Feedback (2) Information (3) Rewards	(1) Individual feedback, information (2) Comparative feedback, information (3) Comparative feedback, information reward (4) Information (5) Control	91	Gas and electricity use	*Electricity use* Attitude (+) *Gas use* Attitude (+) *Pre/post* Attitude (n.s.)	12 weeks	(1) Electricity 18.8% Gas 18.4% (2) Electricity 18.4% Gas 5.8% (3) Electricity 19.4% Gas 17.5% (4) Electricity 7.6% Gas 0% (5) Electricity 5.6% Gas 11.6%		Not measured
Pallak and Cummings (1976)	(1) Commitment	(1) Public commitment (2) Private commitment (3) Control	65 (gas) 142 (elec.)	Gas and electricity use (C)	Not measured	1 month	Public commitment condition showed a lower rate of increase in gas and electricity use than private commitment or control.		*6 months follow-up* This effect was maintained.
Pitts and Wittenbach (1981)	(1) Financial incentive (tax credit)	(1) Incentive	146	Buying home insulation (E)	Not measured		Not measured		*2 years after tax* Tax credit had no effect on insulation purchase decision.
Seligman and Darley (1977)	(1) Feedback	(1) Feedback (2) Control	40	Electricity use (C)	Not measured	1 month	Feedback group used 10.5% less electricity than control.	$d = 0.85$	Not measured
Sexton et al. (1987)	(1) Feedback	(1) Feedback (2) Control	600	Electricity use	Not measured	22 months	Electricity consumption shifted to off peak hours, but total consumption did not decrease.		Not measured
Slavin et al. (1981) *Study 1*	(1) Rewards (2) Feedback (3) Information (4) Prompts	(1) Combination (14 weeks) (2) Combination (12 weeks) (3) Combination (8 weeks)	166	Electricity use	Not measured	8–14 weeks	Combined interventions resulted in savings of 11.2% (group 1), 1.7% (group 2), and 4% (group 3), and an average of 6.2%.		Not measured
Slavin et al. (1981) *Study 2*	(1) Rewards (2) Feedback (3) Information (4) Prompts (5) Goal setting	(1) Combination (14 weeks) (2) Combination (11 weeks) (3) Combination (8 weeks)	255	Electricity use	Not measured	8–14 weeks	Combined interventions resulted in savings of 9.5% (group 1), 4.7% (group 2), and 8.3% (group 3), an average of 6.9%.		Not measured

Table A1 (*continued*)

Author(s)	Intervention(s)	Design	*N*	Target behavior[a]	Behavioral determinants[b]	Duration	Effect during intervention	Effect size	Long-term effect
Staats et al. (1996)	(1) Information (mass media campaign)	N/A	704	Willingness to show pro-environ-mental behaviors (C)	*Pre-post* Knowledge (+) *Of behavior* Knowledge (n.s.) Problem awareness (n.s.)		*After media campaign* Slight increase in willingness to show pro-environmental behaviors, but only for those who already acted pro-environmentally.		Not measured
Staats et al. (2004)	(1) Information (2) Individual feedback (3) Comparative feedback	(1) Information, individual & comparative feedback (2) Control	150	Gas, water, electricity use, waste, food, transport	*Reduce car use* $<5\,km$ Intention (+) Habit (−)	8 months	Gas use: 20.5% Electricity use: 4.6% Water use: 2.8% Waste: 32.1%		*After 2 years* Gas use : 16.9% Electricity use 7.6% Water use: 6.7% Waste: 32.1%
Van Houwelingen and Van Raaij (1989)	(1) Feedback (2) Goal setting (10%) (3) Self-monitoring (4) Information	(1) Continuous feedback, goal setting, information (2) Monthly feedback, goal setting, information (3) Monitoring, goal setting, information (4) Goal setting, information (5) Control	285	Gas use (C)	Not measured	1 year	(1) Continuous feedback: 12.3% (2) Monthly feedback: 7.7% (3) Self-monitoring: 5.1% (4) Information: 4.3% (5) Control: 0.3% All groups significantly reduced gas use compared to baseline levels and compared to control group.	(1) vs. (2): $d = 0.28$ (1) vs. (3): $d = 0.43$	*After 1 year* Gas use increased for all groups, compared to baseline; difference between groups disappeared
Völlink and Meertens (1999)	(1) Feedback (2) Goal setting (3) Information	(1) Feedback, goal setting, information (2) Control	48	Gas, electricity and water use (C)	Not measured	5 months	Experimental group used 18% less water, 23% less gas and 15% less electricity than control.		Not measured
Winett et al. (1978)	(1) Feedback (2) Information (3) Rewards	(1) Information, feedback, high reward (2) Information, feedback, low reward (3) Information, feedback (4) Information (5) Control	129	Electricity use	Not measured	8 weeks	*First 4 weeks:* (1) High reward: 3.5% (2) Low reward: 4.5% (3) Feedback: −1.7% (4) Information: −7.3% (5) Control: 0.9% After 8 weeks: high reward group saved 12%, and information only (now on high rewards) saved 7.6%.		Not measured

Winett et al. (1979)	(1) Feedback (2) Self-monitoring (3) Information (4) Goal setting	(1) Feedback, information, goal setting (2) Monitoring, information, goal setting (3) Control	71	Electricity use (C & E)	Not measured	1 month	Feedback group reduced electricity use by 13% and the self-monitoring group by 7%.	(1) $d = 1.41$ (2) $d = 0.61$	*10-week follow-up* Effect was maintained.
Winettt et al. (1982–1983)	(1) Information (audits)	(1) Audit (2) Control	51	Electricity use (water heating, air-co) (C & E)	Not measured	1 month	After the audit, households reduced electricity use by 21%, relative to the control group.		Not measured
Winett et al. (1985)	(1) Modeling (2) Information	(1) Modeling, information (2) Control	150	Gas and electricity use (C)	*Pre/post* Knowledge (+) *Of energy savings* Knowledge (n.s.)	5 weeks	Exposure to TV program resulted in electricity savings of 10%.		*After 1 year* Effect was not maintained

[a] A "C" refers to curtailment behaviors, an "E" to efficiency behaviors. Some studies did not report which type of behavior was targeted.

[b] With respect to the measured changes in determinants of *energy use* and *energy savings*, there are two possibilities:

(1) Measurement of relationships between determinants and energy use/energy savings by means of a regression analysis:
(+) a positive relationship between determinant and energy use/savings;
(−) a negative relationship between determinant and energy use/savings;
(n.s.) no relationship between determinant and energy use/savings.

(2) Measurement of changes in levels of determinants as a results of the intervention by means of *pretest/post-test* measurements:
(+) an increase of the level of a determinant was observed;
(−) a decrease of the level of a determinant was observed;
(n.s.) no change was observed with respect to the level of a determinant.

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