Energy-related intervention success factors: a literature review

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Abstract
Since the introduction of the Energy Performance for Buildings Directive (EPBD) and the Energy Service Directive (ESD), influencing the energy related behaviour of households is on the policy agenda of the Dutch government. Therefore, the Ministry of Housing commissioned a review study of all relevant literature in the field of energy conservation and consumer behaviour. In total, 2000 references in 37 articles and books were reviewed.

We approached this body of knowledge using the framework of the Intervention Mapping Protocol developed in the health promotion field. This protocol has an applied social-psychological basis and works as follows: developing an intervention that influences behaviour depends on knowing the determinants of that behaviour, and knowing what methods or instruments effectively influence those determinants to stimulate such a change. Based on an analysis of the literature we present:

(1) An analysis of the energy relevant investment behaviour, normal household energy related behaviour and specific energy conservation behaviour.

(2) An analysis of the strongest determinants of behaviour, both internal and external. The strongest internal determinants are knowledge about choices and costs, comfort, visibility and status. Secondary determinants include motivation and attitude related to energy saving. The strongest external determinants are possibility of choice, income, age, type of household and social comparison.

(3) The most effective instruments and their prerequisites include comparison feedback, tailored advice and incentives.

We conclude with a list of critical success-factors, regarding communicative aspects, financial aspects, conditions for implementing parties and preferences of households

Introduction
Diminishing the human causes of global warming concerns many governments. Reducing energy consumption and thereby reducing the emission of CO_2 is an effective means for reaching this goal and is, indeed, stimulated by policy of the Dutch Government. The Ministry of Environment, Housing and Spatial Planning is responsible for reducing the emission of CO_2 in the built environment. And since the Ministry's introduction of the Energy Performance for Buildings Directive (EPBD) with its energy certificates for houses, influencing energy related behaviour of households is on the Dutch policy agenda.

A recent study of the Ministry (Leidelmeijer et al., 2005) [1] [1]revealed that 40 % of households have an energy-inefficient heating behaviour. Therefore, the Ministry of Environment, Housing and Spatial Planning commissioned Maastricht University to study what the possibilities are for influencing energy conservation behaviour in households. We searched and analyzed the literature for answers to the following questions.

1. What is the potential proportion of energy consumed in houses that can be saved through behavioural change?

1. We refer to the literature by a number between brackets.

2. Through what behaviour and by which specific target groups can this energy saving be reached? And what are the determinants of this behaviour?

3. Based on an analysis of the determinants of energy relevant behaviour, how can we achieve a change in behaviour?

Methods

We performed a broad search by classifying literature based on subjects related to energy saving. We found studies about determinants of energy use, energy related behaviour, and studies about instruments and intervention programmes. These were international review studies and project studies related to the Netherlands. By taking two review publications as a point of departure, we identified many relevant articles.

- a review article by Lutzenhiser (1993) [11], which contains about 200 references;
- a book by Nickerson (2003) [5], containing more than 1500 references.

Nickerson's book led us to the website www.cbsm.com for other literature on energy conservation and households This site is an online database with information about community-based social marketing for intervention programs in the field of sustainable behaviour. Furthermore, we consulted experts in the field of energy related behaviour who advised us on relevant recent publications

We organized, screened and summarized the literature by using the Intervention Mapping Protocol (Bartholomew et al., 2005 [4]). The Intervention Mapping Protocol builds, in turn, on the PRECEDE/PROCEED Planning Model (Green and Kreuter,1999 [36]). This model is meant to develop and to evaluate interventions to influence health related behaviour: such as smoking, and dietary behaviour. This model directs initial attention to outcomes, rather than inputs. In other words, begin with the desired outcome and work backwards to determine the desired behavioural change, the necessary preceding factors and in the end the instruments. Intervention Mapping rests on the assumption that designing and planning an intervention strategy that stimulates behavioural change strongly depends on knowing the relevant behaviour, the determinants of that behaviour and knowing what methods effectively influence those determinants to stimulate such a change.

We defined a determinant to be "a complex of factors that mediate or influence behavioural change of a member in the target group". We discern, following Intervention Mapping, two types of determinants:

1. Personal determinants with internal determinants and demographical determinants. Internal determinants are related to the individual and have a social-psychological character. These are easy to influence. Examples are knowledge, attitudes, values and skills to perform the behaviour. Demographical determinants are sex, age, education, income, number of children and household type. These determinants are often used to segment a target group for marketing purposes.

2. External or contextual determinants are related to the context or environment: e.g. whether people have social support, and whether they have access to financial resources and services, price measures, and regulatory measures.

The Intervention Mapping Protocol consists of six steps:
Step 1: Problem analysis, with an analysis of energy relevant behaviour, the determinants and context factors;
Step 2: Choose specific behaviours, determinants and target groups, resulting in program objectives;
Step 3: Select theory- and evidence-based methods and practical techniques;
Step 4: Develop the programme;
Step 5: Make an implementation plan;
Step 6: Make an evaluation-plan.

To answer our research questions, we approached the literature with the following specific questions derived from the Intervention Mapping Protocol.

- Which target behaviours are named and in what detail?
- What are the potential savings?
- Which target groups were mentioned?
- Which determinants are related theoretically with the energy related behaviour and is their influence assessed?
- Which method and techniques are used in the intervention projects?
- Which planned intervention projects are successful?
- What are the success and failure factors as reported by the authors?
- Are evaluation studies performed and how?

Results

In general, we found that most reviewed intervention studies focussed on the intervention and its effect, or on explaining the consumption of energy. Most intervention studies did not clearly define target groups, and had the intention to influence behaviour. The intervention itself was often the focus point. And when determinants were analyzed, it was after the interventions, and the determinants were used to explain the effect of the interventions. In other words, the explaining determinants were often assumed and not well founded.

RESULTS RELATED TO BEHAVIOUR

The literature shows various forms of behaviour:

1. *Energy-relevant investment behaviour.* Investment behaviour contributes to the performance, heat losses and the efficiency of the existing houses and appliances.

2. *Energy-relevant household behaviour.* This behaviour contributes to the energy consumption in the using phase. This concerns pattern of occupation, or the everyday use of appliances. Household behaviour also consists of habits which are energy saving but were not so meant; for example, the closing of curtains for privacy. This type of behaviour has a habitual character.

3. *Energy conservation behaviour.* These active behaviours (at almost zero cost) are undertaken to reduce the use of energy, such as installing weather-stripping or closing the curtains.

Furthermore, the literature makes clear that:

1. It is not easy to identify specific behavioural targets. Many types of conduct contribute a little bit to energy conservation;
2. The opportunities for making large energy savings vary between target groups;
3. The classification "investment behaviour", "household behaviour" and "conservation behaviour" matches the classification which households use;
4. Literature show that households favour small measures and spread these measures over different categories of activities.

RESULTS RELATED TO TARGET GROUPS

From the Leidelmeijer study [1], four target groups in Holland have a savings potential:

1. Elderly people in older one family houses, (low income);
2. Households with an average income;
3. Higher income – two income – households;
4. Households with a professional worker at home.

Other studies in the review revealed many demographical characteristics of target groups, which can be used for segmentation. The most important are age of occupants, type and age of the house, family type, income and the employment situation. Factors that played an important role in the response to interventions include attitude, initial need for information on how to reduce energy, duration of occupancy of the house.

RESULTS RELATED TO SAVINGS POTENTIAL

The proportion of energy consumption and the conservation potential were reported to depend on characteristics of the house, of the household and of the behaviour. Reported savings reached by intervention programmes were: between 0-25 % for gas and 3-22 % for electricity [2; 6; 8; 11; 16; 17; 18; 19; 20; 28; 30; 31]. Based on these ranges, we estimated that through behavioural change Dutch households can potentially save, on average, 12 % on gas (± 10 %) and 7 % on electricity (± 5 %).

The literature reports that households favour small measures that they spread measures over different categories of activities. Examples are: installing energy efficient light bulbs, loading the washing machine optimal, setting at night the thermostat 5 degree, and take shorter showers. Apparently, spreading small measures requires the least effort. Furthermore, households do not choose on the basis of energy conservation advice, but rather on their acquaintance with the measure and their ability to fit the measure in (estimated effort) [27, 29, 31].

RESULTS RELATED TO DETERMINANTS OF INVESTMENT-, HOUSEHOLD- AND CONSERVATION BEHAVIOUR AND ENERGY-USE

In the literature, we found many determinants of "energy use" in general and, although energy-use is not a specific behaviour, we also present these findings.

We have categorized behavioural determinants as "personal" (internal and demographical) and "external". Furthermore, the literature mentions "factors", which are assumed to have an influence on behaviour but, strictly speaking, cannot be seen as determinants of behaviour.

Table 1 presents reported determinants which influence: (1) energy-relevant investment behaviour, (2) energy-relevant household behaviour (3) energy conservation behaviour, and (4) the energy use. In the last column, we estimate the relative strength.

In the table, we have defined determinants of investment behaviour to be knowledge, information about cost, and information about additional characteristics such as comfort, appearance, status, visibility and luxury, the availability of choice possibilities, financial space and the right moment. We defined determinants of energy conservation behaviour to be, firstly, seeing the possibilities for energy conservation and, secondly, the motivation for energy conservation and a positive attitude towards energy conservation and environment. Determinants of energy use were defined to be the personal determinants, attitude and knowledge, positive experience and self-efficacy, and the demographical determinants: income, age and family-phase, household size, and the external determinants construction measures and technical provisions.

Furthermore, the organization of the household and institutional patterns were reported to influence energy-use. In the reported research, however, this influence was generally not taken into account [11]. Besides this, determinants such as possibility of choice, size, type and age of the dwelling, income, age, ethnicity, gender and type of household were found to influence the reaction to different energy conservation interventions [8,11]. Social comparison and social commitment were reported to influence energy use [8,11,15].

We found the explaining power of the determinants to vary considerably. Some authors reported a "proof" in terms of an analysis of variance. But most reported only "strong" suspicions.

INTERVENTIONS SUCCESS FACTORS

We found several different types of intervention methods:

- Communication: information and promotion, training, personal advice, demonstrations, benchmarking, commitment, goal setting, labelling, prompts, modelling, feedback[2];
- Economic incentives and disincentives: subsidy, levies, surcharges, taxes, bonus, tax differentiation, tax refunds, financial constructions such as interest free loans, rewards, penalties, and higher peak rates for electricity;
- Regulatory: general laws and rules, specific exemptions, covenants and agreements.

The effectiveness of the measures were reported to increase when several methods are combined [11,17, 18, 19]. Successful combinations were for example:

2. Feedback is an instrument by which periodically information is given on the actual energy consumption. It raises awareness of energy use and, together with information on how to save energy, it decreases energy consumption by 5-25 % [31].

Table 1 Determinants, type of behaviour, and reference **Determinants**	**Investment behaviour**	**Importance*)**	**House-hold behaviour**	**Importance*)**	**Energy conservation behaviour**	**Importance*)**	**Energy use**	**importance*)**
Internal determinants								
Personal determinants								
Attitude, environmental consciousness, motivation for energy conservation/ responsibility, societal	9	-	7	-	7, 11, 19, 28, 30	+++	7, 19, 27, 33	+
Knowledge, information/ learning need/ cost estimation, product-use	9, 12, 23, 24	+++	7, 9	+++	8, 11, 18,	++	7, 27	++
Self monitoring		-		-	25	++		-
Intention (self set goals)	20	-	20	-	18, 19, 28	++		-
Social comparison	9	-		-	8, 11	+		-
Social contacts	24	+		-	15	+		-
Positive experience	20, 23	+		-	31	+	11	
Behavioural commitment, obligation		-		-	15, 30	+		
Appearance, status, visibility, symbolic value	9, 12, 23	++		-		-		-
Self efficacy		-		-	7, 11, 15, 28	++	11	
Comfort/leisure; optimizing luxury, comfort, functions	9, 11, 12, 23	++		-	11	-		-
Contributing to the environment		-		-	11	-		+
Price- judgement / quality	9, 23	++	9	-	11	-		-
Awareness of monitoring			9	+	31	-	11	-
Demographical factors								
Age, family-phase, becoming of age	1, 19	+		-	8, 30, 11	+	1, 11, 19, 26	+++
Household size	12			-	30	+	1, 2, 11, 19, 21, 25, 26, 33	+++
Gender		-		-	8, 11	-		++
External determinant								
Possibility of choice, problem solving, service, raising standard of living	9, 20, 24	++		-	11,18, 25, 30, 31	++	11, 21	+++
Appropriate moment	1, 9, 11, 12,	++		-		-		-
Income	1, 9, 12,	++		-	11	-	11,19, 26,	++
Organisation household activities		-		-		-	11	-
Contextual factors								
Type dwelling; longer /shorter housing perspective		-		-	12	-	1, 2	+++
Reliability of vendors	9, 15	++		-	8, 11	+		-
Building-shell related measures		-		-		-	1, 2, 11	+++
Provisions in installations		-		-		-	1, 2, 11, 23	+++
***) +++ = important role ++ = play a role + = not so important – not important**								

- Feedback about energy requirement and information;
- Personal advice, physical measures and inquiring regularly after consumption figures;
- Information and advice with setting personal goals;
- Higher peak rates for electricity, with incentives or possibilities for subsidies and credits;
- Interventions aimed at the individual with personalized information combined with incentives.

Evaluation of intervention projects focussed on experiences, on changed behaviours, on changed determinants of behaviours, on energy consumption and on changes in ownership of appliances, or on dwelling characteristics such as insulation rate [9, 10, 13, 16, 19, 31, 37]. We found only two studies that measured the determinants that changed energy-relevant behaviour, as well as the achieved reduction in energy consumption [9, 19]. And only one study was found reporting the evaluation of long-term effects or of rebound effects [19]. Results about the cost effectiveness in relation to the number of addressed households, or saved CO_2 emissions were not found. Several authors reported that success of a programme depends upon intervention programmes being ready on time and techniques and materials and the script are tested before the implementation of the programmes [10, 13, 25, 30, 31, 34].

We also found the continuity of the project, one project leader, and short lines of communication are crucial when parties work together. Also crucial to success were the early participation of actors in pilot tests [13, 14, 15, 31].

For a number of intervention methods, the reviewed literature discussed critical success factors for interventions in general but also for specific interventions such as feedback or

Table 2. Success factors

Communicative aspects	Applicable information (concrete, precise, address a problem, use knowledge and experiences; simple tasks, give examples); Clear, trustworthy, understandable information; Provide the big picture; Use visualization (no cognitive general information); Framing aspects; Readable at a distance (labelling); Good speed, frequency (feedback), Prompts (friendly, easy, at hand) Use goal setting (imposed goal setting and comparison with others; or self-chosen goals and comparison with personal data); Give attention to different aspects in different periods; Combine insulation-programmes with self-registration;
Financial aspects	Make subsidy schemes simple and its conditions attractive; level of subsidy important for low income groups; Provide financial constructions as lease constructions, revolving funds, green loans etc. Make a proper estimation of the costs and of payback time in relation to energy saving in time; Raise knowledge about prices in order to raise sensitivity for energy prices; Use financial instruments in combination with other methods; Methods seem to work better when energy costs are a larger part of household budget; Tariff rates have effect
Conditions for implementing parties	Develop the programme (composition, marketing, and the content) in a systematic way; Clearly define roles and goals; When working with utilities, local governments, and so on: mind the conditions for cooperation; Credibility of the source of information; Take care of the interaction-situation of the target group with its environment Use electronic energy monitoring devices; Reduce the costs and complexity of the energy advice; Provide courses for installers and advisors; Provide good supportive materials, and monitoring instruments; Marketing aspects of the intervention, combined with financial incentives;
Preferences of households	Initial positive intention of households is of relevance; Meeting points such as schools are relevant; Focus on networks; make use of people that know each other; Give assistance, depending on the target group, to take small measures; Use permission marketing; Make use of other than energy related considerations (comfort, status, fashion, health, safety), and programmes (integration, burglar-prevention) to find a motive for households to participate; Take into account household dynamics, lifestyles and relations with institutional patterns.

setting standards [8, 11, 13, 17, 18, 25, 31, 37]. See Table 2 for an overview of the success factors.

Discussion and Conclusions

We first answer and discuss the research questions, then we make some general conclusions and recommendations.

Firstly, the proportion of energy consumed in houses in the Netherlands that can be saved through behavioural change is, on average, 12 % ± 10 % for gas and 7 % ± 5 % for electricity. The exact values depend upon the target group. In energy efficient dwellings, the potential is somewhat lower: 9 % for gas en 4 % for electricity.

Secondly, we cannot say through what behaviour and by which specific target groups this energy saving can be reached. Many different types of behaviour contribute to the conservation of energy. We can, however, categorize household behaviour in investment behaviour, (which is often a rational type of behaviour) and energy relevant household behaviour (which is often of an habitual character). Households prefer to take small measures, which they spread over several categories of activities. For households, the energy savings potential is not the leading factor, but rather their awareness of the measure, and the convenience to carry it out. We found a broad spectrum of determinants influencing energy related behaviour, especially those related to energy conservation behaviour and energy use in general.

Little information exists about determinants of energy-relevant investment behaviour, and even less about energy-relevant household behaviour. Also, the explaining power of behavioural determinants varies considerably. Some authors have reported a "proof" in terms of an analysis of variance, but most of the time there are just "strong" suspicions.

However, we did find that the determinants which explain energy conservation behaviour include seeing possibilities for energy conservation and, secondarily, the motivation for energy conservation and an "environmental" attitude. Determinants of energy use include attitude and knowledge, positive experience and self-efficacy, and external determinants including income, age and family-phase, household size, and house construction and technical provisions. Determinants which explain investment behaviour include knowledge, information about costs and additional benefits of investments, such as comfort, appearance, status, visibility and luxury. Furthermore, the availability of alternatives, the financial resources for investments, and the natural moment play an important role in the decision process.

Thirdly, from our analysis of the determinants of energy relevant behaviour found in the literature, we cannot easily say how we can achieve a change in behaviour. Here, the literature clearly lets us down; we found no intervention strategy based on an analysis of behavioural determinants. We think this is caused because many policy implementers have a focus on the instrument and not on the change which has to be induced.

Concerning the findings in literature on interventions influencing the use of energy, we conclude that effectiveness increases if several methods are implemented in combination. Combinations include:

- Feedback about energy use and giving information;
- Personal advice, physical measures and feedback about energy consumption;
- Information and advice on setting personal goals;
- Higher peak rates for electricity, with incentives or subsidies and credits;
- Interventions with personalized information in combination with financial incentives aimed at the individual.

In general, we conclude that, till now, most intervention studies have an "instrument" orientation. That is, directly after determining the problem, instruments are chosen without determining if they are appropriate to induce the desired changes. Most studies show no "proof" for the relevance of a determinant but only report a strong suspicion. And this is one of the reasons that we found not many relevant studies.

This review highlights a lack of systematic studies, and it lays the groundwork to rationally develop intervention programmes to influence the energy relevant behaviour of households. We recommend a stronger focus on the behaviour of target groups and their determinants and that interventions be based on a more systematic problem-oriented approach. The Intervention Mapping Protocol is an applicable and effective systematic method. Its steps are problem analysis, choosing specific change goals, using evidence based methods and practical techniques, intervention development, intervention implementation (anticipating adoption) and an evaluation-plan. Such a systematic approach will lead to choosing interventions that rationally fit the targeted behaviour and its determinants.

Pragmatically we recommend the further development of the instrument "feedback" in combination with giving information, because energy conservation behaviour is not one specific form of behaviour, but it consists of a set of sub-behaviours. "Feedback" in combination with advice and information influences determinants such as attitude, it is information, appeals to positive experiences and self-efficacy, intention and setting goals. And "feedback" is an appropriate intervention technique to deal with such a diffuse package of behaviours, especially because energy prices are rising and in the Energy Service Directive will make the "smart meter" obligatory in Europe.

Furthermore, because the studies on investment behaviour were limited to only small number of different investments, we recommend further research on large-investment behaviour, such as renovating and insulating houses.

In conclusion, we make a plea for a systematic approach to changing energy-related behaviour. The Intervention Mapping. Protocol offers this needed systematic framework. This review offers a first start in influencing the energy-related behaviour of households.

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