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How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings?

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ABSTRACT

Households constitute an important target group for energy conservation. They not only use energy in a direct way (gas, electricity and fuel) but also in an indirect way (embedded in the production, consumption and disposal of goods). During a period of five months (viz., October 2002–March 2003), direct and indirect energy use and direct and indirect energy savings of 189 Dutch households were monitored. The study examined the relative importance of socio-demographic variables and psychological variables in relation to household energy use and changes in energy use (viz., energy savings). For this purpose, variables from the theory of planned behavior [Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179–211] and the norm activation model [Schwartz, S. H. (1977). Normative influences on altruism. In L. Berkowitz (Ed.). *Advances in experimental social psychology* (Vol. 10, pp. 221–279). New York: Academic Press] were used. Results indicate that energy use is determined by socio-demographic variables, whereas changes in energy use, which may require some form of (cognitive) effort, appear to be related to psychological variables. The variables from the norm activation model were able to significantly add to the explanation of energy savings, over and above the variables from the theory of planned behavior. Also, different types of energy use and energy savings appeared to be related to different sets of determinants.

1. Introduction

Households are responsible for a considerable amount of total greenhouse gas emissions. In the US and Western European countries, households typically account for approximately 15–20% of total energy-related CO_2 emissions and this residential share is expected to keep rising (Biesiot & Noorman, 1999). Households therefore constitute an important target group for energy conservation. If the aim is to encourage households to reduce energy use, it is important to target determinants of energy use and conservation.

The research to date indicates that household energy use appears to be mainly related to socio-demographic variables, such as income and household size, i.e., which shape the opportunities and constraints for energy use (e.g., Biesiot & Noorman, 1999; Gatersleben, Steg, & Vlek, 2002; Moll et al., 2005). Energy use has also been linked to psychological variables, such as attitudes (e.g., Becker, Seligman, Fazio, & Darley, 1981). Changes in energy use (energy savings) may also be dependent on socio-demographic variables and psychological variables. That is, the extent to which households save energy may

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depend on factors that serve as barriers or opportunities for conservation, such as income (e.g., purchase decisions). Equally well, the decision to (try and) reduce energy use implies making a conscious decision and/or entails conscious efforts to realize such energy savings. Psychological variables may therefore also be related to energy conservation. For instance, Brandon and Lewis (1999) found that energy savings were related to attitudes, and not to socio-demographics. The current study aims to expand on the existing body of knowledge by systematically exploring the relationships between energy use and energy savings on the one hand and socio-demographic variables and a comprehensive set of psychological variables on the other. To this end, this study includes variables from the two psychological theories relevant for environmentally significant behavior.

Several authors indicate that different types of environmentally-relevant behavior are related to different behavioral antecedents (e.g., Axelrod & Lehman, 1993; McKenzie-Mohr, Nemiroff, Beers, & Desmarais, 1995; Stern & Oskamp, 1987). In a similar vein, it can be argued that different types of household energy use are related to different behavioral antecedents. Households use energy in a direct way, through the use of gas, electricity and fuel, but also in an indirect way (Vringer & Blok, 1995). Indirect energy use is embedded in the production, transportation and disposal of consumer goods and services. To illustrate, the availability of fruit and vegetables has carbon implications, because of the use of fossil fuels in the transportation and distribution processes. In the Netherlands, approximately half of average household energy use is estimated to be indirect energy use (Reinders, Vringer, & Blok, 2003). If the aim is to encourage households to consume products with lower energy use per unit, it is important to examine indirect energy use and factors related to it. Possibly, as indirect energy use has different characteristics (e.g., it may be relatively unknown or invisible to consumers), it may be related to different variables than direct energy use. Research has mainly focused on factors related to direct energy use. This study aims to fill this gap and focus on the antecedents of indirect energy use as well.

The present study aims to systematically examine whether different types of energy use and savings are related to different behavioral antecedents, with a specific focus on the relative importance of socio-demographic variables and psychological factors. For this purpose, variables were used from two social–psychological theories relevant for explaining environmental behaviors, namely, the theory of planned behavior (TPB; Ajzen, 1991) and the norm activation model (NAM; Schwartz, 1977). The study examines whether the explanatory power of the variables from the theory of planned behavior can be enhanced by the variable from the norm activation model in relation to direct and indirect energy use and direct and indirect energy savings.

2. Factors related to household energy use and energy savings

The theory of planned behavior (Ajzen, 1991) and Schwartz' (1977) norm activation model are often used to examine pro-environmental behavior (Bonnes & Bonaiuto, 2002). The theory of planned behavior (TPB) is considered an example of a rational choice theory (see Lindenberg & Steg, 2007), and assumes that behavior is a result of a reasoned process of weighing costs and benefits of the relevant behavior (in terms of time, money, effort, social approval). Behavior is determined by an individual's intention to perform it. In turn, behavioral intentions are assumed to be determined by attitude, perceived behavioral control, and subjective norm. Attitudes refer to the degree to which a person has a favorable or an unfavorable evaluation of a behavior, and depends on the weighing of various costs and benefits such as financial costs, effort, or time. Perceived behavioral control is the perceived ease or difficulty of engaging in a behavior. Subjective norm refers to the perceived social pressure to perform or to refrain from a behavior, i.e., an individual's perception of the extent to which important others would approve or disapprove of a given behavior. The TPB has been used to explain a wide array of behaviors, such as weight loss and voting choice (see Ajzen (1991) and Armitage and Conner (2001), for reviews). It has also been successfully applied in the area of environmentally relevant behaviors. The use of energy-saving light bulbs, the use of unbleached paper (Harland, Staats, & Wilke, 1999), car use (Bamberg & Schmidt, 2003), and bus use for commuting (Heath & Gifford, 2002) appeared to be adequately explained by variables from the TPB. Generally, perceived behavioral control and attitudes tend to be most strongly related to pro-environmental behaviors and intentions, and subjective norm to a lesser extent (see Armitage & Conner, 2001).

The norm activation model (Schwartz, 1977; Schwartz & Howard, 1981), considers pro-environmental behavior as a form of altruistic behavior, insofar as individuals have to give up personal benefits for the sake of collective interests (i.e., the environment). Altruistic behavior is believed to be determined by (activated) personal norms, which are experienced as feelings of moral obligation. Behavior in accordance with personal norms may lead to a sense of pride, while behavior not in accordance with personal norms may lead to a sense of guilt. Two additional factors are involved in the activation of personal norms. First, a person needs to be aware of the consequences of their own behavior for others or the environment (awareness of consequences). Second, a person needs to feel personally responsible for these behavioral consequences (ascription of responsibility). People who believe energy use has negative environmental consequences and people who feel personally responsible for these problems, will feel a stronger obligation to help solve these problems by reducing their energy use. The NAM has been successfully applied to a range of pro-environmental behaviors, such as recycling (Guagnano, Stern, & Dietz, 1995; Hopper & Nielsen, 1991), and energy conservation (Black, Stern, & Elworth, 1985).

Several studies have extended the TPB with NAM variables, the personal norm concept in particular (see Parker, Manstead, & Stradling, 1995). Personal norms were found to significantly add to the explanation of the TPB for a range of environmentally-relevant behaviors (i.e., the use of energy-saving light bulbs, the use of unbleached paper, meat consumption, and car use for short distances; Harland et al., 1999). Another study indicates that the NAM variables personal norms, awareness of consequences and ascription of responsibility could not significantly add to the explanation of intention to use the bus and (self-reported) bus use – over and above the TPB variables (Heath & Gifford, 2002). This suggests that the explanatory power of the NAM concepts (in addition to TPB) may vary for different behaviors. Many personal advantages are attached to both energy use (such as increased comfort) and energy conservation (such as monetary savings). Equally well, energy use and conservation may also be related to altruistic considerations, e.g., concern for environmental consequences (Samuelson, 1990), suggesting that the NAM variables may explain additional variance over and above that of the TPB variables.

This study aims to investigate, first, whether energy use and changes in energy use are related to different variables, and, second, whether direct and indirect energy use and direct and indirect energy savings are related to different determinants. This is done by means of examining the relative importance of socio-demographic variables and psychological variables in relation to (direct and indirect) household energy use and (direct and indirect) energy savings. It is examined whether variables from the NAM can explain additional variance – in addition to TPB variables – in household energy use and savings.

In line with previous research (e.g., Brandon & Lewis, 1999), we hypothesize that household energy use is more strongly related to socio-demographic variables (i.e., factors that provide opportunities and constraints for energy use) than to psychological variables. Specifically, we expect income and household size to be positively related to household energy use. As changes in energy use require a certain amount of conscious effort (to make the decision to change), we hypothesize that energy savings will be mainly determined by psychological variables (cf. Brandon and Lewis, 1999). In particular, more positive attitudes towards energy conservation and higher levels of perceived behavioral control will be associated with higher energy savings. In view of results of previous studies (e.g., Harland et al., 1999), subjective norm was not included in this study. In addition to the variables from the TPB, we expect environmental concerns to be motivators for behavioral change. Specifically, we expect that awareness of consequences, ascription of responsibility and personal norms will be positively related to energy savings.

3. Method

3.1. Participants

An internet-based questionnaire study was conducted. The study took place in Groningen, a city of approximately 180,000 inhabitants in the northern part of the Netherlands. A request letter including a free response card was distributed in August 2002 to 6000 customers of a Dutch utility company. Households had to meet several criteria to be eligible for participation. Access to the Internet was obviously a first requirement. Further, households who had moved residence in the year preceding the study or had plans to do so during the course of the study were excluded, because previous year's energy use was used for calculating energy savings. Households who did not have own gas and/or electricity meters were also excluded, because meter readings were used to calculate energy savings. The initial sample who eventually took part in the study consisted of 314 households. Households were randomly assigned to the experimental and the control group. Analyses of variance for the continuous data and Chi-square analyses for the categorical data indicated that randomization appeared to be successful. There were no significant differences in socio-demographic characteristics (income, household size, age, gender), and in direct and indirect energy consumption between households in the experimental and control conditions.

The study took place over a period of five months. Households in the experimental group filled out the online questionnaires at three fixed times. The first measurement took place before implementation of the interventions (October 2002), the second and third measurements took place two and five months after implementation of the interventions (December 2002 and March 2003, respectively). Households in the control group were asked to fill out the online questionnaires at two fixed points in time. These coincided with the first (before the intervention) and third measurement (five months after the intervention) of the experimental groups. Therefore, in this paper, we will only focus on the first and third measurement, which will be referred to as before measurement and after measurement, respectively.

The intervention study was aimed at encouraging households to reduce their direct as well as indirect energy use. This was done by means of providing households in the experimental group with tailored information on how they could reduce energy use (viz., custom-made information for their specific situation). They were given information about effects of changing behaviors related to their gas, electricity and fuel use (direct energy use), and were also specifically given information about how they could reduce their indirect energy use, by changing their purchase decisions (e.g., meat consumption; avoid throwing away food). They were given a goal of 5% energy savings to attain. Households received feedback on how much energy they had saved (in relation to the 5% goal). During the five-month intervention period, energy use, changes in energy use (viz., energy savings) and psychological variables (e.g., attitude) were monitored. Results reveal that households who were exposed to the intervention (i.e., information, goal setting, and feedback) saved an average 5.1% on their energy consumption. Household in the control group (who were not exposed to any intervention) increased their energy use by 0.7%. A more detailed account of the effectiveness of the interventions to encourage energy savings can be found elsewhere (Abrahamse, Steg, Vlek, & Rothengatter, 2007; Benders, Kok, Moll, Wiersma, & Noorman, 2006). Those papers specifically focus on the effect of tailored interventions to encourage reductions in household energy consumption (i.e., the how). The present paper focuses on the factors related to household energy use and savings (i.e., the why). Future interventions can be developed more effectively when determinants of energy use and energy savings are taken into consideration.

3.2. Procedure and materials

Participating households were asked to fill out online questionnaires measuring direct and indirect energy use and behavioral antecedents (e.g., socio demographics, attitudes, perceived behavioral control), before and after implementation of the intervention. On both occasions, the same household member filled out the surveys via the Internet.

First, a questionnaire was used to estimate direct and indirect energy use as well as the behavioral antecedents of participating households before the interventions were implemented. Energy use was calculated based on possession and use of appliances, and various energy-related behaviors. It encompassed both efficiency behaviors such as purchase decisions and curtailment behaviors, such as thermostat settings (see Gardner & Stern, 2002). More specifically, participants were asked to indicate which appliances they owned (e.g., dishwasher, clothes dryer), and how often they used them, the extent to which their house was equipped with insulation (e.g., cavity wall insulation, double glazing), and to what extent they performed various energy-related behaviors for direct energy use (e.g., thermostat setting, showering time, use of energy-saving light bulbs) and indirect energy use (e.g., food consumption, waste). Based on these data, direct and indirect energy use was estimated by means of a sophisticated tool developed by environmental scientists (see Benders et al., 2006). This tool estimated direct and indirect energy use for each individual household by adding the energy requirements associated with possession and use of different household appliances, as well as various energy-related behaviors. Furthermore, socio-demographics (e.g., income, household size) and behavioral antecedents were measured. In the measurement five months after implementation of the intervention, direct and indirect energy use were measured again, and based on changes in energy use, as calculated by the online tool, direct and indirect energy savings were estimated (Benders et al., 2006). Again, behavioral antecedents were measured.

3.3. Sample of participants

The study took place in Groningen, a city of approximately 180,000 inhabitants in the Netherlands. A total of 314 households completed the questionnaire before implementation of the intervention. Households with higher incomes were overrepresented in this sample. Average age of respondents was 42.3 years ($SD = 11.96$); 64.1% of respondents were men. Average household size was 2.5 (i.e., number of people in the household) and is in accordance with the Dutch average of 2.3 (Statistics Netherlands, 2009). Of these households, 23.3% were single-person households, 35.6% two-person households, and 41.1% consisted of three persons or more. Homeowners were also overrepresented (73%). Average gas use of participating households in 2001 (the year preceding the experiment) was 1636 m^3 ($SD = 736$), which is somewhat lower than the Dutch average of 1965 m^3. Average electricity use in 2001 of 3048 kWh ($SD = 1557$) was also lower than the Dutch average of 3230 kWh.

Not uncommon to longitudinal studies, a substantial number of households dropped out during the course of the study. Total attrition from pretest to the second posttest (after five months) was 39.9% ($N = 123$). To examine the nature of attrition, a comparison was made between households who dropped out and those who remained of their average scores on annual gas and electricity use, household size, net monthly household income, age, gender, and the behavioral antecedents (attitudes, perceived behavioral control, awareness of consequences, ascription of responsibility, personal norm). This was done for the experimental group and the control croup separately. In the control group, no differences were found between those who dropped out and those who did not. In the experimental group, household members who dropped out during the course of the study tended to be slightly younger ($M = 40.15$ years) than those who remained ($M = 44.56$ years): $F(1, 129) = 4.19$, $p < .05$. Also, households who had dropped out appeared to have higher levels of problem awareness than those who remained ($M = 4.6$ versus $M = 4.4$; $F(1, 135) = 7.27$, $p < .01$). No other significant differences emerged, suggesting that dropout was not too selective – at least as far as the key variables in this study are concerned. The final dataset of households that had completed questionnaires before and after the intervention consisted of 189 households.

3.4. Dependent measures

3.4.1. Energy use (before measurement)

Household energy use was estimated by means of the aforementioned tool, developed by the environmental scientists (see Benders et al. (2006) for a more detailed description). Households were first asked to indicate which household appliances they owned (e.g., clothes dryer, washing machine) and how often they used these appliances. This was done on a household level, i.e., for all household members combined. Then, the energy 'contents' of these behaviors were assessed. This way, not only direct energy use was estimated (the use of electricity, fuels and natural gas), but also indirect energy use (associated with the production, distribution and disposal of goods). Next, the energy contents of possession and use of appliances, and various energy-related behaviors were summed, yielding the total energy use related to a given behavior pattern of a specific household.

3.4.2. Energy savings (after measurement)

Energy savings were calculated on the basis of changes in self-reported behavior – after implementation of the intervention. Based on changes in possession and use of appliances, and changes in energy-related behaviors, changes in energy use between the first measurement (before the intervention) and the final measurement (after the intervention) were calculated.

Table 1
Means, standard deviations for the psychological variables (first and last measurement), $N = 189$.

		First measurement (before intervention)			Last measurement (after intervention)		
		M	*SD*	α	*M*	*SD*	α
Theory of planned behavior							
Attitude	ATT	4.0	.88	.74	3.8	.88	.77
Perceived behavioral control	PBC	3.1	1.11	n/a	3.1	1.15	n/a
Norm activation model							
Personal norm	PN	3.8	.83	.60	3.7	.89	.74
Awareness of consequences	AC	4.4	.66	.59	4.4	.75	.75
Ascription of responsibility	AR	3.8	1.06	.84	3.8	1.01	.86

All scales run from one 'negative' to five 'positive'.

These energy savings referred to the change in energy use (in Mega Joules) since the start of the project (the absolute change, not the percentage change). Direct and indirect energy use in the after measurement was compared to the before measurement. The difference between the two referred to direct (gas, electricity and fuel) and indirect (food consumption, waste) energy savings in Mega Joules since the start of the study (again, these refer to the absolute change, not percentage change).

3.5. Independent measures

3.5.1. Socio-demographic variables

Households were asked to indicate the total (for all household members combined) net monthly income in Euros (in 2002, 1 Euro = \$0.95). This was done on a five-point scale, with 1 'less than 1000' (5.6% of households), 2 '1000–1500' (12.7%), 3 '1500–2000' (20.4%), 4 '2000–2500' (20.7%), and 5 'more than 2500' (40.6%). Household size (i.e., head count; $M = 2.5$, $SD = 1.14$) and age ($M = 42.4$, $SD = 11.96$) were both measured on interval scales.

3.5.2. Behavioral antecedents

All items representing the variables from the TPB and the NAM were measured twice: before the intervention (before measurement) and five months later (after measurement). Responses were given on five-point Likert scales, with scores ranging from 1 'disagree' to 5 'agree', unless otherwise indicated. See Table 1 for an overview of the descriptive statistics for these variables.

3.5.3. Attitude

Four items were used to measure respondents' attitude toward energy conservation ("Energy conservation is too much of a hassle", "Energy conservation means I have to live less comfortably", "My quality of life will decrease when I reduce my energy use", and "It takes up too much of my time to reduce energy use"). The four items comprised a reliable measure for attitudes: Cronbach's alpha's – indicating construct reliability – of the before and after measurement were .74 and .77, respectively. All items were recoded, so as to make a higher score reflect a more positive attitude towards energy conservation.

Perceived behavioral control referred to the extent to which respondents felt capable of conserving energy at home and was measured with three items ("I know how I can save energy", "I find it difficult to reduce my energy use" and "I can reduce my energy use quite easily"). However, the items combined did not form a reliable scale, and a reliable two-item scale could not be created either ($\alpha < .40$). Based on face validity, it was decided to use the latter statement as a single-item measure of perceived behavioral control. A higher score indicates that respondents felt more capable of reducing energy use.

Personal norm was measured with three items that referred to the extent to which individuals felt a moral obligation to conserve energy ("I feel morally obliged to reduce my energy use, regardless of what other people do", "I feel guilty when I use a lot of energy" and "I feel good about myself when I do not use a lot of energy"). These items were measured before and after the intervention: Cronbach's alpha was (only) .60 for the before and .74 for the after measurement. Higher scores indicated stronger feelings of moral obligation to reduce energy use.

Awareness of consequences was measured with three items referring to the extent to which respondents believed energy use to be a societal problem ("The greenhouse effect is a problem for society", "Energy conservation contributes to a reduction of the greenhouse effect" and "The depletion of fossil fuels is a problem"). Cronbach's alpha's for the before and after measurement were (only) .59 and .75, respectively. A higher score indicates a higher sense of awareness of consequences.

Ascription of responsibility was measured with three items and reflected the extent to which respondents felt responsible for energy-related problems ("I take joint responsibility for the depletion of energy resources", "I feel jointly responsible for the greenhouse effect" and "I take joint responsibility for environmental problems"). These items formed a reliable scale, with Cronbach's alpha's of .84 and .86 for the before and after measurement. A higher score indicates stronger feelings of responsibility for energy-related problems.

Table 2
Correlations between energy use, socio-demographic variables and psychological variables (before measurement), $N = 189$.

	1	2	3	4	5	6	7	8	9
1. Energy use									
2. Income	.41**								
3. Household size	.40**	.38**							
4. Age	.07	.05	−.05						
5. Gender	.13	.23*	.29**	.14*					
6. Attitude	−.14	−.13	−.16*	−.06	−.06				
7. Perceived behavioral control	.03	−.06	−.02	−.03	.03	.19*			
8. Personal norm	−.04	.01	.09	.04	−.10	.24*	.06		
9. Awareness of consequences	.00	.02	.10	−.11	−.11	.22*	.13	.42**	
10. Ascription of responsibility	.00	.07	.11	−.07	−.04	.13	.18*	.49**	.57**

Note: income scale runs from one 'less than 1000 Euro per month" to five "more than 2500 Euro per month". For gender, one represents 'female' and two 'male'. All scales for the psychological variables range from one 'negative' to five 'positive'.
* $p < .05$, two-tailed.
** $p < .001$, two-tailed.

4. Results

Correlation and regression analyses were preformed to test our hypotheses. Hierarchical regression analyses[1,2] were performed with (direct and indirect) energy use and (direct and indirect) savings as dependent variables. In the first step, the explanatory power of attitude and perceived behavioral control (TPB) was examined, and in the second step, the additional explanatory power of awareness of consequences, ascription of responsibility, and personal norm (NAM) was explored. In the final step, socio-demographic variables were included – in line with theoretical assumption that socio-demographic variables indirectly influence behavior (Ajzen & Fishbein, 1980). The regression model explaining energy savings included a variable representing treatment (intervention versus control group), to ensure that the possible effect of the intervention on energy savings was controlled for.

4.1. Factors related to energy use

4.1.1. Correlations between energy use and behavioral antecedents (before measurement)

As can been seen in Table 2, household energy use was related to both income ($r = .41$, $p < .001$) and household size ($r = .40$, $p < .001$), and not to psychological variables. Income and household size were also related ($r = .38$, $p < .001$). Socio-demographic variables did not appear to be related to psychological variables. Only attitude and household size were somewhat related: household members from larger households tended to have less positive attitudes towards energy conservation ($r = -.16$, $p < .05$). Higher levels of perceived behavioral control were (modestly) positively related to attitudes towards energy conservation ($r = .19$, $p < .05$). Respondents with higher levels of awareness of consequences felt more responsible for energy-related problems ($r = .57$, $p < .001$), and felt a stronger moral obligation to reduce energy use ($r = .42$, $p < .001$). Levels of responsibility were positively related to feelings of moral obligation to reduce energy use ($r = .49$, $p < .001$). Higher levels of perceived behavioral control were related to stronger feelings of responsibility ($r = .18$, $p < .05$), and more positive attitudes towards energy conservation were related to stronger feelings of moral obligation to reduce energy use ($r = .24$, $p < .05$), and higher levels of awareness of consequences ($r = .22$, $p < .05$).

4.1.2. Explaining energy use (before measurement)

Explaining total energy use

As can be seen in Table 3, attitude and perceived behavioral control were hardly able to contribute to the explanation of the variance in household energy use ($R = .15$, $R^2 = .02$, $F(2, 186) = 2.14$, *ns*). Personal norm, awareness of consequences, ascription of responsibility could not explain any additional variance ($R^2_{change} = .00$, $F_{change}(3, 183) = .05$, *ns*). The socio-demographic variables were able to explain an additional 23% of the variance in household energy use: $R^2_{change} = .23$, $F_{change}(4, 182) = 13.92$, $p < .001$. Taken together, behavioral antecedents and socio-demographics explained about one quarter (26%) of the variance in household energy use $R = .50$, $R^2 = .26$, $F(9, 179) = 6.81$, $p < .001$. Household size appeared to be positively associated with energy use ($\beta = .31$, $t = 4.10$, $p < .001$).[3] Also, households with higher incomes tended to use more energy than those with lower incomes ($\beta = .30$, $t = 4.17$, $p < .001$).

[1] In this section, whenever we talk about the relationship between the criterion and a certain predictor variable, this association only holds for this particular regression model, i.e., it describes the nature of this particular relationship while the other predictor variables are controlled for.
[2] Assumptions of the regression model were checked – and did not appear to be violated.
[3] Standardised regression coefficients (beta's) refer to the association between predictor and criterion variable, in such a way that an increase of one unit in the standardised predictor variable is associated with an increase/decrease of a certain number of units (i.e., the amount reflected in the beta) of the standardised criterion variable. This holds for all regression coefficients reported in Section 4.

Table 3
Regression results for total, direct and indirect energy use on TPB (Step 1), TPB extended with NAM (Step 2) and socio-demographics (Step 3) (before measurement).

		Total energy use					Direct energy use					Indirect energy use				
		β	t	R^2	ΔR^2	ΔF	β	t	R^2	ΔR^2	ΔF	β	t	R^2	ΔR^2	ΔF
1	Attitude	−.15	−2.03*	.02	.02	2.14	−.15	−2.00*	.03	.03	2.56	−.10	−1.39	.01	.01	1.07
	PBC	.06	.78				.11	1.42				−.02	−.20			
2	Attitude	−.15	−2.03*	.02	.00	.05	−.16	−2.10*	.03	.00	.26	−.09	−1.17	.01	.00	.12
	PBC	.06	.72				.10	1.35				−.02	−.21			
	PN	−.02	−.20				.01	.08				−.04	−.45			
	AC	.03	.32				.07	.80				−.03	−.31			
	AR	.00	.04				−.02	−.22				.03	.31			
3	Attitude	−.05	−.66	.26	.23	13.92***	.09	1.17	.13	.10	5.05**	.02	.25	.30	.29	18.50***
	PBC	.07	1.10				.11	1.55				.01	.10			
	PN	−.06	−.73				−.03	−.35				−.07	−.91			
	AC	.01	.10				.05	.56				−.04	−.51			
	AR	−.04	−.43				−.04	−.43				−.02	−.24			
	Income	.30	4.18***				.11	1.38				.41	5.99***			
	Household size	.31	4.19***				.28	3.54**				.24	3.30**			
	Age	.08	1.17				.06	.83				.07	1.12			
	Gender	−.05	−.72				−.07	−.96				−.01	−.14			

PBC, perceived behavioral control; PN, personal norm; AC, awareness of consequences; AR, ascription of responsibility.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Explaining direct energy use

Attitudes and perceived behavioral control contributed (marginally) significantly to the explanation of the variance in direct energy use ($R = .16$, $R^2 = .03$, $F(2, 186) = 2.56$, $p = .08$). When the other predictors were controlled for, a more positive attitude toward energy conservation was associated with lower direct energy use: $\beta = -.15$, $t = -2.00$, $p < .05$. The variables from the NAM did not contribute significantly to the model ($R^2_{change} = .00$, $F_{change}(3, 183) = .26$, *ns*). Socio-demographic variables explained an additional 10% of the variance in direct energy use: $R^2_{change} = .10$, $F_{change}(4, 179) = 5.05$, $p < .01$. Taken together, the psychological and socio-demographic variables were able to explain 13% of the variance ($R = .36$, $R^2 = .13$, $F(9, 179) = 2.95$, $p < .001$). Direct energy use tended to be positively associated with household size ($\beta = .28$, $p < .001$) – when the other variables were controlled for.

Explaining indirect energy use

Indirect energy use was not related to the TPB variables ($R = .11$, $R^2 = .01$, $F(2, 186) = 1.07$, *ns*), nor to the NAM variables ($R^2_{change} = .00$, $F_{change}(3, 183) = .12$, *ns*). Socio-demographic variables explained an additional 29% of the variance in indirect energy use ($R^2_{change} = .29$, $F_{change}(4, 179) = 18.50$, $p < .001$). Taken together, TPB, NAM, and socio-demographic variables explained 30% of the variance ($R = .55$, $R^2 = .30$, $F(9, 179) = 8.60$, $p < .001$). Indirect energy use was positively associated with income ($\beta = .41$, $t = 5.99$, $p < .001$) and household size ($\beta = .24$, $t = 3.30$, $p < .01$).

4.2. Factors related to energy savings

4.2.1. Correlations between energy savings and behavioral antecedents (after measurement)

Energy savings were related to perceived behavioral control: the more respondents thought they were capable of saving energy, the more energy they tended to save ($r = .24$, $p < .05$). Energy savings did not appear to be related to socio-demographic variables. The correlation matrix shows a similar pattern of relationships between the psychological variables as in the first measurement (see Table 4).

4.2.2. Explaining energy savings

Explaining total energy savings

When controlled for treatment (intervention group versus control group), attitude and perceived behavioral control were able to explain (a small amount of) the variance in total energy savings: $R = .26$, $R^2 = .07$, $F(3, 184) = 4.35$, $p < .01$ (see Table 5). Households with higher levels of perceived behavioral control tended to save more energy than those with lower levels of perceived behavioral control ($\beta = .25$, $t = 3.31$, $p < .01$). Inclusion of personal norm, awareness of consequences and ascription of responsibility slightly increased the amount of variance explained: $R^2_{change} = .05$, $F_{change}(3, 181) = 3.21$, $p < .05$. PBC remained a significant predictor. When the other variables were controlled for, households with higher levels of ascription of responsibility appeared to save less energy than those with lower levels of responsibility ($\beta = -.30$, $t = -3.01$, $p < .01$). Socio-demographic variables did not explain any additional variance in total energy savings: $R^2_{change} = .02$, $F_{change}(4, 177) = 1.13$, *ns*.

Explaining direct energy savings

Treatment, attitude and perceived behavioral control significantly explained the variance in direct energy savings: $R = .26$, $R^2 = .07$, $F(3, 184) = 4.35$, $p = .01$. Households exposed to the interventions saved more direct energy than households in the

Table 4
Correlations between energy savings, motivational factors and socio-demographic variables (after measurement), $N = 189$.

	1	2	3	4	5	6	7	8	9
1. Energy savings									
2. Income	.00								
3. Household size	.05	.38**							
4. Age	.11	.05	−.05						
5. Gender	.10	.23*	.29**	.14*					
6. Attitude	.00	−.15*	−.13	.04	.04				
7. Perceived behavioral control	.24*	.02	.04	−.07	.05	.04			
8. Personal norm	−.03	−.10	−.04	.03	−.15*	.32**	.12		
9. Awareness of consequences	.01	.08	.05	.00	−.03	.12	.12	.45**	
10. Ascription of responsibility	−.14	.03	.02	−.03	−.08	.15*	.14	.55**	.64**

Income scale runs from one 'less than 1000 Euro per month' to five 'more than 2500 Euro per month'. For gender, one represents 'female' and two 'male'. All scales for psychological variables run from one 'negative' to five 'positive'.
* $p < .05$, two-tailed.
** $p < .001$, two-tailed.

Table 5
Regression of total, direct and indirect energy savings, controlled for treatment, for the variables from TPB (Step 1), TPB extended with NAM (Step 2) and socio-demographics (Step 3) (second measurement).

		Total energy savings					Direct energy savings					Indirect energy savings				
		β	t	R^2	ΔR^2	ΔF	β	t	R^2	ΔR^2	ΔF	β	t	R^2	ΔR^2	ΔF
1	Treatment	.09	1.23	.07	.07	4.35**	.28	3.94***	.10	.10	7.12***	.02	.28	.04	.05	2.8*
	Attitude	.02	.23				.05	.67				.01	.07			
	PBC	.24	3.31**				.15	2.13*				.21	2.90**			
2	Treatment	.12	1.51	.11	.05	3.21*	.28	3.97***	.11	.00	.22	.04	.53	.09	.05	3.16*
	Attitude	.01	.08				.04	.58				−.01	−.07			
	PBC	.25	3.53***				.15	2.09*				.23	3.13**			
	PN	.04	.41				−.01	−.15				.04	.48			
	AC	.17	1.84				.07	.78				.16	1.71			
	AR	−.30	−3.01**				−.06	−.55				−.30	−3.00**			
3	Treatment	.11	1.55	.14	.02	1.13	.27	3.90***	.15	.04	2.15	.05	.63	.12	.03	1.45
	Attitude	.01	.18				.04	.50				.00	.05			
	PBC	.26	3.58***				.14	1.90				.23	3.25**			
	PN	.04	.39				.00	.01				.04	.40			
	AC	.17	1.80				.07	.73				.16	1.70			
	AR	−.29	−2.89**				−.06	−.58				−.29	−2.88**			
	Income	−.04	−.53				−.09	−1.12				−.02	−.26			
	Household size	.05	.59				.16	2.03*				.01	.09			
	Age	.13	1.80				−.10	−1.47				.16	2.27*			
	Gender	.05	.61				.07	.92				.03	.40			

Notes: treatment = experimental condition (control = 0, intervention = 1).
PBC, perceived behavioral control; PN, personal norm; AC, awareness of consequences; AR, ascription of responsibility.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

control group ($\beta = .28$, $t = 3.79$, $p < .001$). Perceived behavioral control was positively associated with direct energy savings ($\beta = .15$, $t = 2.09$, $p < .05$). The variables from the norm activation model ($R^2_{change} = .00$, $F_{change}(3, 181) = .22$, *ns*) and the socio-demographic variables ($R^2_{change} = .04$, $F_{change}(4, 177) = 2.15$, *ns*) were hardly able to explain any additional variance in direct energy savings.

Explaining indirect energy savings

Indirect energy savings could be significantly explained by treatment, attitude and perceived behavioral control ($R = .21$, $R^2 = .04$, $F(3, 184) = 2.88$, $p < .05$). Perceived behavioral control was a significant predictor of indirect energy savings, while treatment was not. The variables from the NAM were able to significantly add to this ($R^2_{change} = .05$, $F_{change}(3, 181) = 3.16$, $p < .05$), and the socio-demographic variables were not ($R^2_{change} = .03$, $F_{change}(4, 177) = 1.45$, *ns*). Taken together, 12% of the variance in indirect energy savings was explained by the psychological and socio-demographic variables, when controlled for treatment ($R = .35$, $R^2 = .12$, $F(10, 177) = 2.44$, $p < .05$). When the other variables were controlled for, higher levels of perceived behavioral control were associated with higher indirect energy savings ($\beta = .23$, $t = 3.25$, $p < .01$), while higher levels of ascription of responsibility were associated with lower indirect energy savings ($\beta = -.29$, $t = -2.88$, $p < .01$). Older respondents tended to save more indirect energy than younger respondents did ($\beta = .16$, $t = 2.27$, $p < .05$).

5. Discussion

The present study examined the extent to which socio-demographic and psychological factors were related to household energy use and energy savings, and whether direct and indirect energy use and savings were related to different behavioral determinants. For this purpose, it was examined whether variables from the norm activation (NAM) model would explain additional variance in energy use and energy savings when variables from the theory of planned behavior (TPB) are controlled for.

Overall, as expected, the results obtained in this study indicate that household energy use appeared to be related to different variables than energy savings are. Energy use was mainly determined by socio-demographic variables, lending additional support to previous findings (cf. Brandon & Lewis, 1999; Gatersleben et al., 2002). Households with higher incomes and households larger in size tended to use more energy. This suggests that constraints and opportunities strongly shape household energy consumption patterns. Psychological variables were not influential in explaining energy use. The finding that households with higher incomes use more energy may be self-evident. However, to put it in a different perspective, households with higher incomes also have relatively more possibilities to adopt (costly) energy-saving measures, such as the purchase of in-home insulation, by which their energy use could be reduced substantially.

Results for changes in household energy use show a mirror image to this. Household energy savings appeared to be mostly associated with psychological factors, whereas socio-demographics did not come into play. When controlled for the possible effect of treatment (i.e., intervention versus control group), attitude and perceived behavioral control were able to explain the variance in energy savings to some extent, and personal norm, awareness of consequences and ascription of responsibility improved the explanatory power significantly. More specifically, higher levels of perceived behavioral control and lower levels of responsibility were associated with greater energy savings.

Initial support was obtained for our claim that different categories of energy use are related to different sets of variables, supporting the observation that different types of behaviors are related to different determinants (e.g., Axelrod & Lehman, 1993). Direct energy use was related to household size, while indirect energy use was related to income and household size. When controlled for the effect of the intervention, direct energy savings could hardly be explained by either psychological variables or socio-demographic variables. Indirect energy savings were explained by perceived behavioral control and ascription of responsibility. For direct energy savings, we found an effect of treatment, while for indirect energy savings this was not the case. The intervention mainly appeared to have encouraged direct energy savings, overriding the potential role of psychological and socio-demographic variables. For indirect energy savings, the effect of treatment was not significant, potentially allowing the psychological and socio-demographic variables to come into play. This is an intriguing finding, for which an explanation cannot be easily given on the basis of data collected for this study. Other factors not included in this study may be influential (e.g., monetary considerations). This seems reasonable as the amount of variance explained was relatively low, indicating that a wide(r) range of (psychological) variables is needed to better understand and explain household energy use and conservation. More research on direct and indirect energy savings is needed to explore this issue.

In this study, the variables from the NAM were able to significantly explain additional variance in energy savings, over and above that of attitudes and perceived behavioral control (TPB). The evidence pertaining to the additional explanatory power of NAM in relation to TPB is mixed. Harland et al. (1999) found the NAM variable personal norms to add to the power of TPB in explaining environmentally related behaviors. However, Heath and Gifford (2002) did not find personal norms, awareness of consequences or ascription of responsibility to explain variance in addition to the TPB variables. A possible explanation for these inconsistent findings may be that the extent to which moral or altruistic considerations play a role in addition to individual (reasoned) considerations may depend on the way a situation is framed (Lindenberg & Steg, 2007). The Heath and Gifford study examined bus rider ship among students and these students had paid a (mandatory) fee for a bus pass (whether they used the pass or not), i.e., the situation was framed as a cost-benefit frame. This may explain why TPB variables were related to behavior, while NAM variables could not add to this explanation. As in our study, the respondents in the Harland et al. study participated in an energy conservation study, and because environmental consequences were highlighted, this may have activated a normative frame. This may explain why the variables from the NAM were influential – in addition to the variables from the TPB.

In terms of the characteristics of the sample, participation in this study was voluntary, which may have resulted in a sample of respondents who were already interested in energy conservation issues. Also, only one household member was asked to fill out the survey. It was not deemed feasible to have each household member fill out the full-length questionnaire, and as such, it was not possible to examine the extent to which household members have different opinions, or to look at the dynamics within a household when it comes to energy conservation. Becker et al. (1981) collected data from both spouses in a household – they found that correlations between attitudinal variables were relatively high, indicating a certain degree of correspondence in attitudes of spouses toward energy conservation. In view of the above-mentioned issues, some caution in generalizing the results of this study to the wider population is therefore warranted.

Taken together, these results indicate that energy consumption is determined by socio-demographic variables, whereas energy savings (viz., changes in behavior) are mainly determined by psychological factors. This makes sense, to the extent that contextual variables such as income shape households' opportunities for energy consumption, whereas reductions in energy use require conscious efforts to change behaviors/adopt energy-saving measures. The present study also found some indication that direct and indirect energy use and direct and indirect energy savings are determined by different sets of variables. The finding that energy savings are related to psychological variables may be important from a policy perspective, as interventions or policy measures (at least in the Dutch context) aimed at promoting energy savings may want to target specific (psychological) variables (such as enhancing levels of perceived behavioral control). When taking the multifaceted nature of household energy use and savings and the different antecedents into account, more effective interventions may be implemented to encourage households to reduce direct as well as indirect energy consumption.

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