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Factors Related to Household Energy Use and Intention to Reduce It: The Role of Psychological and Socio-Demographic Variables

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Abstract

This study explored the relationships between household energy use and householders' intention to reduce their energy use on the one hand, and psychological variables and socio-demographic variables on the other. More specifically, the study examined whether the explanation of household energy use and intentions to reduce it could be informed by variables from the theory of planned behavior (TPB; Ajzen, 1985) and by variables from the value-belief-norm theory (VBN; Stern, et al., 1999), alongside socio-demographic variables. Household energy use appeared to be most strongly related to socio-demographic variables (income, household size, age), while attitudinal variables and self-transcendence values (tradition/security and power/achievement) were important too. Intention to reduce household energy use was positively related to perceived behavioral control and attitudes toward energy conservation. Implications of these results for future research in the domain of household energy use and conservation are discussed.

Keywords: *energy conservation; households; behavioral antecedents; theory of planned behavior; value-belief-norm theory*

Introduction

Daily consumer activities contribute (at least in part) to increased emissions of greenhouse gases into the atmosphere. Households are responsible for a considerable amount of these emissions, through the combustion of fossil fuels (OECD, 2002). Energy efficiency has increased over the last decades, due to the introduction of technological innovations (e.g. appliances with lower energy usage) and improved in-home insulation. However, more and more appliances have become available, and are increasingly being used by households, hereby counterbalancing initial efficiency gains. As a consequence, household energy use has risen (Biesiot & Noorman, 1999). Technological innovations seem insufficient to reduce energy use; it is equally important to encourage households to change their energy-related behavior patterns.

Household gas and electricity consumption is strongly related to socio-demographic variables, such as income and household size (Moll et al., 2005; Vringer & Blok, 1995). By and large, households with higher incomes use more energy, as do households larger in size. In other words, opportunities and constraints seem to determine how much energy a particular household uses. Some studies have examined attitudinal variables only (i.e. without including socio-demographics) in relation to energy consumption. Becker, Seligman, Fazio, & Darley (1981) for instance found that gas use was related to householder's attitudes towards (thermal) comfort and convenience. A number of studies have included attitudinal variables as well as socio-demographics (Brandon & Lewis, 1999; Gatersleben, Steg, & Vlek, 2002; Poortinga, Steg, & Vlek, 2004). Gatersleben and colleagues (2002) for instance found that household energy use was weakly related to environmental attitudes, while income and household size were better predictors of household energy use. Further, Brandon and Lewis (1999) and Poortinga and colleagues (2004) found that household energy use was not related to environmental attitudes. Typically, these studies included only few psychological variables, and did not use psychological theories to inform the relationships between psychological variables and energy consumption. This present study builds on the existing body of research by including a wider set of psychological variables in relation to household energy consumption, next to socio-demographic variables.

Intentions to reduce energy use are generally linked to

psychological variables, rather than socio-demographics. Relatively few studies have examined intentions to reduce energy use. Householders' intentions to reduce their energy use have been found to be related to attitudes towards energy conservation and perceived behavioral control (Midden & Ritsema, 1986). It may be assumed that behavioral intentions require a certain amount of conscious effort, because they involve a certain amount of planning and deliberation, and are therefore strongly related to psychological variables. However, as Stern and colleagues (1999) rightly point out: 'capabilities and constraints determine the efficacy, real and perceived, of an individual's taking particular actions.' (p. 83). This would imply that intentions to reduce energy use may not only be related to psychological variables, such as perceived behavioral control (viz. perceived constraints), but to socio-demographic variables (viz., real constraints) as well, as these reflect possibilities and constraints for energy conservation. It is therefore important to examine both socio-demographic and psychological factors in relation to behavioral intentions.

The studies described above suggest that household energy use may be particularly predicted by socio-demographic variables, while psychological variables have little impact. Arguably, socio-demographic variables influence the possibilities and constraints that people face, which in turn affect energy use (e.g., high income groups can afford bigger houses and more appliances, and as a consequence use more energy). Intentions to reduce energy use seem to be more strongly related to psychological variables, probably because intentions to reduce energy are voluntary in nature and may be less constrained by contextual factors as is energy use. In other words, intentions may particularly depend on the perceived costs and benefits of energy conservation, as reflected in psychological variables, such as attitudes towards energy conservation and perceived behavioral control.

This study examines the relationships between household energy consumption and householders' intentions to reduce it on the one hand and socio-demographic and psychological variables on the other. As indicated above, most studies included a limited set of psychological variables. As a consequence, we may conclude that psychological variables are only weak predictors of household energy use, while in fact the studies did not include a comprehensive set of psychological variables. To rule out this possibility, we will test the predictive power of two prominent theories to explain environmental behavior. We will examine to what extent each theory separately, as well as combined, can explain household energy use and intentions to reduce it, and to what extent socio-demographics are able to explain additional variance in the data when the psychological variables are controlled for. Below, we briefly describe the two theories used in our study: the theory of planned behavior, and the value-belief-norm theory.

The theory of planned behavior

The theory of planned behavior (TPB, Ajzen, 1985; Ajzen & Fishbein, 1980) is a widely applied theoretical framework for explaining behavior and behavior change. According to the TPB, the most proximal predictor of behavior is the intention to perform it. Behavioral intentions are an indication of the extent to which people are willing to try to perform the behavior in question. In turn, intentions are assumed to be determined by attitudes, subjective norms, and perceived behavioral control. Attitudes refer to the degree to which a person has a favorable or unfavorable evaluation of a given behavior. For instance, households may refrain from lowering temperature settings in the winter time, because they feel that it will compromise comfortable living. Subjective norms refer to individual perceptions of the extent to which important others would endorse a given behavior and individual motivations to comply with this social pressure. For instance, householders who think family members will disapprove of them lowering thermostat settings, and who take their opinions regarding this matter on board, will be less likely to adopt this energy-saving measure. Perceived behavioral control refers to the perceived ease or difficulty of engaging in a behavior. Householders may not be willing to reduce energy use, because they do not feel able to do so.

The TPB assumes that structural variables, such as socio-demographics influence intentions and behavior indirectly (Ajzen & Fishbein, 1980). That is, psychological variables are assumed to mediate the relationship between socio-demographic variables and behavior. Empirical support for the TPB is abundant for a range of energy-related behaviors (for reviews see Ajzen, 1991; Armitage & Conner, 2001), such as car use (e.g., Bamberg & Schmidt, 2003), energy conservation (Harland, Staats, & Wilke, 1999) and bus use (Heath & Gifford, 2002). The TPB assumes that people make planned, rational decisions, typically motivated by self-interest (in terms of hassle, or social approval). Because of this, the TPB variables may be especially relevant in explaining behaviors involving relatively high cost (in terms of cost, effort, convenience), such as car use or energy use (Lindenberg & Steg, 2007).

Value-belief-norm theory of environmentalism

The value-belief-norm theory (VBN; Stern, Dietz, Abel, Guagnano, & Kalof, 1999; Stern, 2000) was specifically developed to explain environmental behavior. The VBN theory proposes a causal chain of variables, going from basic, general val-

ues and beliefs to behavior-specific beliefs and norms to behavior. The model extends Schwartz' norm activation model (1977) by integrating general values and environmental concern.

General values are at the very beginning of the proposed causal chain. Values are conceived of as guiding principles in people's lives (Rokeach, 1973). Schwartz (1992, 1994) states that values can be categorized along two dimensions: self-transcendence (viz., concern for others) versus self-enhancement (viz., concern for self), and openness to change (viz., variation) versus conservatism (viz., tradition). Self-transcendence values appear to be related to a range of pro-environmental intentions and/or behaviors (e.g. Joireman, Lasane, Bennett, Richards, & Solaimani, 2001; Karp, 1996; Stern & Dietz, 1994; Stern et al., 1999; Nordlund & Garvill, 2003). Poortinga et al. (2004) found that acceptability of domestic energy-saving measures was (negatively) related to self-enhancement values.

According to the VBN theory, general values are related to a person's environmental concern, as reflected in the new environmental paradigm (NEP; see Dunlap, Van Liere, Mertig, & Jones, 2000). As such, the values people hold are indicative of how they see themselves in relation to the environment. As a next step, environmental concern is related to the extent to which individuals believe their own behavior has negative environmental consequences (i.e. awareness of consequences). People with a stronger concern for the environment will be more aware of the environmental impact of their actions. Next, the more people are aware of these consequences, the more likely it is that they will assume responsibility for environmental problems (i.e. ascription of responsibility). In turn, feelings of responsibility will lead to the activation of personal norms (moral obligation to act). Feelings of moral obligation are assumed to be positively related to willingness to act pro-environmentally and actual pro-environmental behaviors.

The VBN theory has been used to explain relatively 'low cost' behaviors (cf. Lindenberg & Steg, 2007), such as acceptability of policy measures, intentions to reduce car use and recycling. Support has been obtained for parts of the VBN theory (e.g. Gärling, Fujii, Gärling, & Jakobsson, 2003; Guagnano, Stern, & Dietz, 1995; Nordlund & Garvill, 2003; Poortinga et al., 2004), and for the mediating relationships between variables (Kaiser, Hübner, & Bogner, 2005; Steg, Dreijerink, & Abrahamse, 2005). According to Stern (personal communication, 2006), the VBN theory assumes that socio-demographic variables act as opportunities and constraints for behavior. This would suggest that psychological variables mediate the relationship between socio-demographic variables and behavior (as is the case in the TPB).

This study aims to test the predictive power of psychological variables vis-à-vis socio-demographics in explaining household energy use and intentions to reduce it. We first test the predictive power of the TPB and VBN variables separately. Next, we test the predictive power of both models combined, to examine whether a comprehensive set of psychological variables will explain additional variance in energy use and intentions to conserve energy. Finally, we test whether socio-demographic variables explain additional variance in the data when the psychological variables are controlled for.

In light of the different focus of the two theories, as explained above, we expect that the TPB and VBN variables are differently related to energy use and behavioral intentions. Specifically, we expect that energy use, which can be considered to involve relatively high cost (cf. Lindenberg & Steg, 2007) will be more strongly related to the TPB variables (reflecting attitudes, perceived possibilities) than to the VBN variables (reflecting environmental values, beliefs and norms) (Hypothesis 1). Conversely, as behavioral intentions can be considered to involve relatively low costs, we expect the VBN variables to be more strongly related to intentions to reduce energy use than the TPB variables (Hypothesis 2). Further, we expect that the combined model of TPB and VBN variables will be better able to explain energy use and intentions to reduce it, compared to the models separately (Hypothesis 3). Finally, we expect that household energy use is more strongly influenced by socio-demographic factors, while psychological factors play a minor role (Hypothesis 4). In contrast, we expect intentions to be more strongly influenced by psychological variables, while socio-demographic variables are less important (Hypothesis 5).

Method

This study was part of an intervention study aimed at encouraging households to reduce their energy use. Energy use and behavioral antecedents were measured before and after implementation of the intervention. Given the purpose of the present paper, we focus on the factors related to household energy use and intentions to reduce it, that is, before any intervention took place.

Participants and procedure

A request letter including a free response card was distributed in the summer of 2001 to some 7,000 customers of a Dutch utility company. Households were asked to participate in a study aimed to test a newly developed website, which would provide them with custom-made information about energy-saving measures. These measures were specifically focused on reducing their gas and electricity use at home. In order to validly evaluate the effectiveness of the intervention, households had to meet several criteria to be eligible for participation, viz., access to the Internet, no plans to move resi-

dence during the course of the study, and having own gas and electricity meters (to exclude master-metered households). Non-response analysis revealed that no access to the Internet was the most important reason for households to refrain from participation.

A total of 199 households completed the questionnaire before the intervention. The sample is not fully representative of the Dutch population; it is not known whether the sample is representative of Dutch Internet users. Households with higher incomes were overrepresented: 18% had a net monthly income lower than 3500 guilders, 49% had an income between 3500 and 5500 guilders, and 33% had an income higher than 5500 guilders (in 2001, 1 Dutch guilder = 0.45 Euro = $0.41). Average household size was 3.0 (Sd = 1.25), whereas the Dutch average was 2.3. With 8%, single-person households were underrepresented (compared to the Dutch average of 33%). Some 36% of the households consisted of two persons, and 56% of three persons or more. Age of respondents ranged between 25 and 77, with an average of 47 years (Sd = 10.36). Three-quarters of the sample were male respondents. Average energy use of participating households was higher than the Dutch average: gas use in the year preceding the study was 1949 m^3 (Sd = 861), compared to the Dutch average of 1764 m^3 and average electricity use was 3769 kWh (Sd = 1557), compared to the Dutch average of 3083 kWh.

Dependent measures

Household energy use was calculated based on meter readings, and was composed of annual gas and electricity use of the year preceding the study (i.e. the year 2000). To be able to add gas and electricity use, both measures were transformed into Mega Joules (1 m^3 gas = 31.65 MJ and 1 kWh electricity = 10 MJ). Average energy use was 99,195 MJ (Sd = 36,494). Ten households were omitted from further analyses, because of large deviations (>500%) from average gas and/or electricity use. Apparently, these households did not record their meter readings correctly. Because temperatures are generally higher in the southern part of the Netherlands, a dummy variable representing region (north or south) was included in the regression analyses aimed to explain energy use, to correct for the influence of outside temperature on energy use.

Intention to reduce energy use was measured by asking respondents to indicate the percentage of energy they were intending to save during the course of the study. Scores ranged from 0 to 35%, with an average of 7.7% (Sd = 5.09).

Independent measures

Socio-demographic variables. Households were asked to indicate the total net monthly income in Dutch guilders (for all household members combined). This was done on a five-point scale, with 1 'less than 1500', 2 '1500-2500', 3 '2500-3500', 4 '3500-4500', 5 '4500-5500', and 6 'more than 5500'. Gender (of the household member who filled out the questionnaire) was coded as a dummy variable, with 1 'male' and 2 'female'. Household size (M = 3.1, Sd = 1.23) and age (M = 46.9, Sd = 10.41) were both measured on interval scales.

Psychological variables were measured on five-point Likert scales, and scores ranged from 1 'strongly agree' to 5 'strongly disagree', unless otherwise indicated. When applicable, items were recoded so as to make higher scores reflect higher levels of a certain construct.

TPB variables

Five items were used to measure respondents' attitude towards 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", "Energy conservation will restrict my freedom" and "Energy conservation is not very enjoyable"). On average, households had a positive evaluation of energy conservation (α = .74; M = 3.8, Sd = .53).

Subjective norm (SN) was measured by asking respondents to what extent they thought they ought to be conserving energy. Four reference groups were used, i.e. 'my friends', 'the government', 'my household/family members', and 'my neighbors'. No reliable scale (alpha < .40) could be constructed, presumably because the reference groups are quite diverse in nature, and they may have been perceived by respondents as having different expectations about energy conservation. It was decided to use a single-item measure of subjective norm, namely the extent to which household/family members accepted a social norm in favor of energy conservation, as it was thought to be the reference group most relevant for domestic energy conservation. On average, households were neutral with respect to whether their household/family members were in favor of energy conservation (M = 3.0, Sd = .98).

Perceived behavioral control (PBC) referred to the extent to which respondents felt capable of conserving energy at home ("I know how I can save energy", "I do not think it will be difficult to reduce my energy use by 5%", "I think it is realistic to reduce my energy use by 5%", and "I can reduce my energy use quite easily"). On average, households were neutral with respect to their perceived ability to conserve energy (α = .75; M = 3.3, Sd = .64).

VBN variables

Following Poortinga, et al. (2004), we used a list of 22 so-called Quality of Life (QoL) indicators to measure values (see Table 1). This list was based on the Schwartz Value Inventory (Schwartz, 1994). Respondents were asked to rate how important each aspect of quality of life was to them, on a scale from 1 'very important' to 7 'not important at all'. All

items were recoded so as to make higher scores indicate higher importance ratings. A Principal Components Analysis with Varimax rotation was conducted. Five factors had eigenvalues larger than 1, explaining 62.1% of the variance.

Table 1 shows the factor loadings of the 20 QoL Indicators on the five factors after Varimax rotation; the items 'work' and 'identity' were ommitted from further analyses as they had factor loadings lower than .50 on any of the factors.

Table 1. Factor loadings of the Quality of Life (QoL) Indicators after Varimax Rotation (see text for factor interpretations)

	Factor				
	1	2	3	4	5
Aesthetic beauty being able to enjoy the beauty of nature	.80				
Leisure time having enough leisure time to spend as one wishes	.77				
Nature being able to enjoy nature	.70				
Freedom having the freedom to decide things for oneself	.67				
Justice having equal opportunities	.57				
Privacy having the opportunity to a space of your own	.56				
Environmental quality having access to clean air and soil; good environmental quality	.52		.57		
Material beauty having nice possessions in and around the house		.81			
Money, income having enough income to buy the things you want and need		.79			
Status, recognition getting respect and appreciation from others		.77			
Comfort, convenience having a comfortable daily life		.69			
Health being in good health, having access to good health care			.84		
Partner, family having a significant other, stable family life and good family relations			.57		
Social relations establish and maintain good relations with friends, colleagues, neighbors			.52		
Safety being safe at home and in the streets, being protected against crime			.50		
Challenge, excitement having challenges and experience exciting things				.75	
Change/variation having a varied life, experiencing as many things as possible				.70	
Education, development being able to get good education and expand one's general knowledge				.50	
Spirituality being able to practice any religion or spiritual persuasion					.76
Security feeling cared for by others					.71
Eigenvalue	7.02	2.48	1.75	1.28	1.14
Explained variance	31.9	11.3	8.0	5.8	5.2

Note: Only items with factor loadings higher than .50 are displayed.

The aspects aesthetic beauty, leisure time, nature, freedom, justice, and privacy correlated highly with each other and constitute the first factor, reflecting a combination of what Schwartz has labeled universalism and self-direction values. Based on conceptual considerations, it was decided to include the item 'environmental quality' in the universalism/self-direction value dimension. On average, respondents rated the universalism/self-direction values as rather important (α = .84; M = 6.2; Sd = .62).

The values material beauty, money/income, status/recognition, and comfort/convenience constitute the second factor, reflecting what Schwartz labels power/achievement values. Taken together, these items formed a reliable construct, with an α of .81, and an average importance rating of 4.8 (Sd = .96).

The third factor reflects Schwartz' cluster of traditional values: health, partner/family, social relations, and safety. The combined scale was acceptably reliable with an a of .66, and an average rating of 6.5 (Sd = .47).

The items challenge/excitement, change/variation and education/development were highly related and formed the fourth factor. This factor can be interpreted as the stimulation/openness to change value cluster in the Schwartz typology (α = .70; M = 5.5; Sd = .85).

The items loading on the fifth factor — the values spirituality and security — could not be combined to form a reliable scale (α < .50), and were omitted from further analyses.

The revised version of the New Environmental Paradigm (Dunlap et al., 2000) was used to measure environmental concern. Households had relatively high levels of environmental concern (α = .70; M = 3.9, Sd = .44).

Awareness of consequences (AC) was measured with three items referring to the extent to which respondents believed energy use to be a 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 societal problem"). On average, households were aware of the environmental consequences of energy use (α = .68; M = 4.1, Sd = .53).

Ascription of responsibility (AR) 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"). On average, respondents felt somewhat responsible for energy-related problems (α = .80; M = 3.7, Sd = .65).

Personal norm (PN) 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 would consider myself a better person if I used less energy"). Cronbach's α was acceptable (.67). People responded rather neutrally, with an average of 3.1 (Sd = .73).

Results

A series of regression analyses was conducted to test our hypotheses. We conducted hierarchical regression analyses with energy use and intention to reduce energy use as dependent variables. First, results for the variables from the theory of planned behavior are presented, followed by results for the variables from the value-belief-norm theory. We then present the results of a combined model, including the TPB and the VBN variables, followed by a model which includes the psychological variables from both theories and the socio-demographic variables.[1,2]

Relationships between TPB variables, household energy use and intention to reduce it

The variables from the theory of planned behavior were hardly able to explain any variance in household energy use: (R = .22, R^2 = .05, F (3,182) = 3.06, p < .05). When the other TPB variables were controlled for, respondents with more positive attitudes towards energy conservation (β = -.20, t = -2.75, p < .01) tended to use less energy (see Table 2).

About 18% of the variance in intention to reduce energy use could be explained by attitude, subjective norm, and perceived behavioral control R = .42, R^2 = .18, F (3,181) = 12.84, p < .001. Respondents with higher levels of perceived behavioral control (β = .36, t = 5.21, p < .001) and more positive attitudes towards energy conservation (β = .17, t = 2.47,

Table 2. Regression results for the variables from the theory of planned behavior, household energy use and intention to reduce it (N = 186).

	Energy use					Intention to reduce energy use				
	β	t	R	R^2	F	β	t	R	R^2	F
			.22	.05	3.06*			.42	.18	12.84***
Attitude	- .20	- 2.75**				.17	2.47*			
Subjective Norm	.04	.52				.02	.28			
PBC	.10	1.35				.36	5.21***			

Note: *** p < .001, ** p < .01, * p < .05.

Table 3. Regression results for variables from the value-belief-norm theory, household energy use and intention to reduce it a (N = 168).

	Energy use					Intention to reduce energy use				
	β	t	R	R^2	F	β	t	R	R^2	F
			.38	.15	3.38**			.23	.05	1.11
PN	- .08	- .99				- .01	- .11			
AR	.05	.56				- .20	- 2.05*			
AC	- .03	- .25	.09	.85						
NEP	- .10	-1.06				- .06	- .67			
Uni/Self	- .05	- .46				.01	.09			
Power/ Ach	.25	2.67**				-.10	- 1.02			
Trad/Sec	.27	2.95**				.03	.28			
Open/ Stim	- .23	-2.61*				.20	2.09*			

Note: PN= Personal Norm, AR = Ascription of Responsibility, AC = Awareness of Consequences, NEP = New Environmental Paradigm, Uni/Self = Universalism/Self-direction values, Pow/Ach = Power/Achievement values, Trad/Sec = Tradition/Security values, Open/Stim = Openness to change/Stimulation values
** p < .01, * p < .05.

$p < .05$) appeared to have stronger intentions to reduce energy use. Subjective norm did not contribute to the explanation of intentions when attitudes and perceived behavioral control were controlled for.

Relationships between VBN variables, household energy use and intention to reduce it

The VBN variables were able to explain 15% of the variance in energy use: $R = .38$, $R^2 = .15$, F (8,159) = 3.38, $p < .01$. When the other VBN variables were controlled for, the more importance households attached to values related to tradition and security ($\beta = .27$, $t = 2.95$, $p < .01$) and power and achievement ($\beta = .25$, $t = 2.67$, $p < .01$), the more energy they tended to use. In contrast, the more importance they attached to openness to change values, the less energy they tended to use ($\beta = -.23$, $t = -2.61$, $p < .05$). Intention to reduce energy use could not be significantly explained by the VBN variables ($R = .23$, $R^2 = .05$, F (8,158) = 1.11, ns).

Relationships between psychological and socio-demographic variables, household energy use and intention to reduce it

We first tested the predictive power of the TPB and VBN variables combined and next studied to what extent socio-demographic variables explained additional variance in energy use and intentions to reduce it. As outlined earlier, in line with the assumption of the TPB and the VBN theory that the psychological variables mediate the relationship between socio-demographics and intention/behavior (Ajzen, and Fishbein, 1980; Stern et al., 1999), first, the TPB and VBN variables were entered, followed by the socio-demographic variables (see Table 4).[3]

The variables from the TPB and VBN accounted for 20% of the variance in energy use: $R = .45$, $R^2 = .20$, F (11,150) = 3.43, $p < .001$. Respondents with more positive attitudes towards energy conservation used less energy ($\beta = -.20$, $t = -2.53$, $p < .05$). The more importance households attached to values related to tradition and security ($\beta = .30$, $t = 3.19$, $p < .01$) and to power and achievement values ($\beta = .21$, $t = 2.19$, $p < .05$), the more energy they tended to use. The more importance they attached to openness to change values, the less energy they tended to use ($\beta = -.22$, $t = -2.57$, $p < .05$).

When socio-demographic variables were entered in the regression model, an additional 23% of the variance in energy use was accounted for ($R^2_{change} = .23$, F_{change} (5, 145) = 11.65, $p < .001$). Taken together, the psychological and socio-demographic variables explained 43% of the variance in energy use $R = .66$, $R^2 = .43$, F (5, 145) = 6.83, $p < .001$. Respondents with more positive attitudes towards energy conservation ($\beta = -.15$, $t = -2.12$, $p < .05$) used less energy. Energy use was positively related to tradition and security values ($\beta = .30$, $t = 3.54$, $p < .01$) and power and achievement values ($\beta = .19$, $t = 2.24$, $p < .05$), and negatively related to openness to change values ($\beta = -.16$, $t = -2.02$, $p < .05$). As expected, households in the southern part of the Netherlands used less energy than their northern counterparts ($\beta = -.21$, $t = -3.13$, $p < .01$). In line with our hypotheses, households with higher incomes tended to use more energy than households with lower incomes ($\beta = .33$, $t = 4.88$, $p < .001$). Household size was positively associated with energy use ($\beta = .30$, t = 4.34, p < .001), as was age ($\beta = .22$, $t = 3.02$, $p < .01$).

The variables from TPB and VBN accounted for 28% of the variance in intentions to reduce energy use: $R = .52$, $R^2 = .28$, F (11,149) = 5.13, $p < .001$. Respondents with higher levels of perceived behavioral control ($\beta = .43$, $t = 5.98$, $p < .001$) and more positive attitudes towards energy conservation ($\beta = .18$, t = 2.38, $p < .05$) appeared to have stronger intentions to reduce energy use. Respondents who felt a stronger responsibility for problems related to energy use, tended to have weaker intentions to reduce their energy use

Table 4. Regression results for variables from the theory of planned behavior and the value-belief-norm theory, socio-demographic variables, household energy use and intention to reduce it (N = 162).

	Energy use					Intention to reduce energy use				
	β	t	R^2	ΔR^2	ΔF	β	t	R^2	ΔR^2	ΔF
Model 1			.20	.20	3.43***			.52	.28	5.13
Attitude	- .20	- 2.53*				.18	2.38*			
SN	.09	1.13				-.00	- .02			
PBC	.14	1.80				.43	5.98***			
PN	- .10	- 1.23				- .01	- .09			
AR	.10	1.02				- .19	- 2.15*			
AC	- .02	- .21				.01	.07			
NEP	- .04	- .44				- .06	- .96			
Uni/Self	- .06	- .58				.00	.04			
Power/ Ach	.21	2.19*				-.13	- 1.39			
Trad/Sec	.30	3.19**				.01	.10			
Open/ Stim	- .22	- 2.57*				.22	2.61*			
Model 2			.43	.23	11.65***			.07	.02	.88
Attitude	-.15	- 2.12*				.19	2.41*			
SN	.08	1.31				.02	.30			
PBC	.09	1.27				.43	5.79***			
PN	- .11	- 1.54				- .01	-.12			
AR	.05	.57				- .19	- 2.06*			
AC	- .06	- .69				.01	.09			
NEP	.03	.37				- .08	- .86			
Uni/Self	- .06	- .64				- .01	-.10			
Power/Ach	.19	2.24*				- .13	- 1.41			
Trad/Sec	.30	3.54**				.04	.44			
Open/ Stim	- .16	- 2.02*				.20	2.37*			
Region	- .21	- 3.13**								
Income	.33	4.88***				.02	.33			
Hh Size	.30	4.34***				.00	.03			
Age	.22	3.02**				.02				
	.29									
Gender	.01	.15				- .10	- 1.34			

Note: PN= Personal Norm, AR = Ascription of Responsibility, AC = Awareness of Consequences, NEP = New Environmental Paradigm, Uni/Self = Universalism/Self-direction values, Pow/Ach = Power/Achievement values, Trad/Sec = Tradition/Security values, Open/Stim = Openness to change/Stimulation values, Hh Size = Household Size

*** p < .001, ** p < .01, * p < .05.

(β = -.19, t = -2.15, p < .05). The more importance respondents attached to openness to change values, the stronger their intentions to reduce their energy use (β = .22, t = 2.61, p < .05).

Socio-demographic variables hardly explained any additional variance in intentions: R^2_{change} = .01, F_{change} (4, 145) = .71, ns. Taken together, the psychological and socio-demographic variables explained 29% of the variance in intentions to reduce energy use R = .53, R^2 = .29, F (15, 145) = 3.86, p < .001. Intentions to reduce energy use were positively related to perceived behavioral control (β = .43, t = 5.79, p < .001) and attitudes towards energy conservation (β = .19, t = 2.41, p < .05), and negatively related to ascription of responsibility (β = -.19, t = -2.06, p < .05). The more importance respondents attached to openness to change values, the stronger their intentions to reduce their energy use (β = .20, t = 2.37, p < .05).

Discussion

This paper examined whether household energy use and intention to reduce energy use could be explained by psychological and socio-demographic variables. For this purpose, we used two prominent psychological theories (i.e. the theory of planned behavior and the value-belief-norm theory) to inform the relationships between a comprehensive set of psychological variables and household energy consumption. This study examined to what extent each theory separately, as

well as combined, was able to explain household energy use and intentions to reduce it, and to what extent socio-demographics were able to explain any additional variance.

In contrast to our first hypothesis, the variables from the theory of planned behavior were hardly able to explain any variance in household energy consumption. Only attitudes towards energy conservation were positively related to energy use. Previous studies have tended to find (weak) relationships between attitudinal variables and energy use as well (e.g. Gatersleben et al., 2002). The variables from the value-belief-norm theory in contrast were much better able to explain energy use. In particular, values related tradition/security, power/achievement, and openness to change appeared to be important predictors of household energy use. Interestingly, values reflecting self-enhancement were influential, whereas self-transcendence values were less important. These results are in contrast with many previous findings, which generally reveal that particularly self-transcendence values are important predictors of environmental behavior (e.g. Joireman et al ,2001; Karp, 1996; Stern & Dietz, 1994; Stern et al., 1999; Nordlund & Garvill, 2003). The findings of this study suggest that in addition to attitudinal variables, values are important variables to take into consideration in relation to energy use.

In contrast to our expectation, intentions to reduce energy consumption were mainly related to the variables from the theory of planned behavior. In particular, householders with higher levels of perceived behavioral control and more positive attitudes towards energy conservation had stronger intentions to reduce their energy use. Subjective norm was not significantly related to behavioral intentions. This may be due to the fact that a single item rather than a composite measure of subjective norm was used. Earlier findings do indicate that social norms may not necessary play a role in the explanation of intention to conserve energy (see Midden & Ritsema, 1986).

The variables from the value-belief-norm theory were unable to significantly explain behavioral intentions. Other studies have found relationships between AC, AR, moral norms and intention or behavior (e.g. Nordlund & Garvill, 2003; Steg et al., 2005). It may well be that some types of behavioral intentions (such as intentions to reduce energy use) are related to TPB variables reflecting individual (cost/benefit) considerations, whereas other types (e.g. intention to recycle) show a stronger relationship with VBN variables such as environmental values and beliefs. Future research should be aimed at systematically examining whether different types of environmental behaviors and intentions are indeed related to different sets of variables.

In line with our third hypothesis, the variables from the combined models were able to explain more variance in both energy use and intentions to reduce it. This highlights the importance of using a comprehensive set of psychological variables in relation to household energy use. This is underscored by the fact that in the combined model, variables from both models (i.e. attitudes and values) were important predictors of energy use and intentions to reduce it.

In line with our expectations, energy use was more strongly explained by socio-demographic variables, than by the psychological variables from the TPB and VBN combined. Households in the southern parts of the Netherlands used less energy than their northern counterparts; probably due to regional temperature differences. Households with higher incomes and households larger in size used more energy than those with lower incomes and those smaller in size. In addition, older respondents tended to use more energy than younger respondents. It appears that socio-demographic variables act as opportunities and constraints for energy consumption patterns. These findings are in line with previous studies (e.g. Brandon & Lewis, 1999; Gatersleben et al., 2002; Poortinga et al., 2004). In addition, the psychological variables from the TPB and VBN were related to household energy use, when the socio-demographic variables were controlled for. In particular, attitudes towards energy conservation and values appeared to be important predictors of household energy use. Crucially, these results highlight that psychological variables indeed play an important role in the explanation of household energy use, in contrast to what the previous research in the area seems to suggest. This highlights the importance of incorporating a comprehensive set of theory-based psychological variables, rather than only including a limited set of attitudinal variables (e.g. Brandon & Lewis, 1993).

In line with our fifth hypothesis, intention to reduce energy use was more strongly related to the psychological variables from the combined models, while socio-demographic variables hardly explained any additional variance. In particular, intentions to reduce energy use were related to attitudes towards energy conservation and perceived behavioral control. Interestingly, ascription of responsibility was negatively related to behavioral intentions, indicating that stronger feelings of responsibility for environmental problems were associated with weaker intentions to reduce energy consumption when the other psychological variables are controlled for. This has also been found in a study on intentions to reduce car use (Abrahamse, Steg, Gifford, & Vlek, 2009).

Our study focused on outcomes of behavior, and we obtained a reliable composite measure of household energy use (i.e. gas and electricity use). Household energy use is comprised of various energy-related behaviors, and the use of meter readings allows for an overall measure of energy consumption. As such, a composite measure provides an indication of the extent to which households act pro-environmentally across a range of energy-related behaviors. In addition,

meter readings provide an impact measure of environmental behavior — in terms of energy use and carbon dioxide emissions — which is highly valuable from an environmental impact point of view (Stern, 2000). Because of this, we sought to examine antecedents of an aggregate measure of energy use, rather than focusing on antecedents of specific energy-related behaviors. The psychological constructs used to explain energy use were all measured at the same level of specificity as the dependent variables, i.e. they were measured at the outcome level (viz., energy use). Our study adds to an extensive body of literature in which outcome measures have been used as proxies of measures of behavior patterns and related to psychological and socio demographic variables. For instance, psychological factors have been examined in relation to gas use (Becker et al., 1981), energy use (Gatersleben et al., 2002; Poortinga et al., 2004) and water use (Aitken, McMahon, Wearing, & Finlayson, 1994). The findings of these studies, and the present one, indicate that psychological variables are able to explain some proportion of the variance in the outcome behavior in question — which seems to suggest that such an approach is useful.

In this study, household energy use and intention to reduce energy use were measured on a household level, whereas some socio-demographic variables (gender, age) and all psychological variables were measured on an individual level (i.e. household members who filled out the questionnaires). This was done out of practical considerations. It was not feasible to ask each household member to fill out the full-length questionnaire. Equally well, it was impossible to examine the energy use of each individual household member as household energy use cannot simply be divided by the number of people in a household because it is not clear what the individual shares are. We chose a 'second best' option, that is, the household member who filled out the questionnaire was assumed to represent the entire household with respect to the psychological variables.

Due to the number of criteria for eligibility for this study, participation rate was rather low, and because the study was specifically targeted at Internet users, the sample was not representative of the general population. Also, since average scores on constructs such as awareness of consequences were already relatively high, it is likely that a motivated sample of households took part in the study (i.e. already interested or engaged in energy conservation). International polls (e.g. Franzen, 2003) do indicate that members of the Dutch public generally have a high environmental awareness. This notwithstanding, caution in generalizing the present results is warranted.

In conclusion, the results of the current study suggest that household energy use is strongly related to factors that shape the opportunities for energy use (viz., income, household size), but that psychological variables play a role too. Attitudes towards energy conservation and self-enhancement values (viz., tradition and power/achievement) were related to household energy use. Intention to reduce energy use on the other hand, appeared to be most strongly related to psychological variables, namely, the extent to which households feel capable of reducing their energy use, and the extent to which they have a positive or negative evaluation of energy conservation.

Household energy conservation can be achieved through strengthening behavioral intentions. The results of this study suggest that in that case, attitudes towards energy conservation and perceived possibilities for conserving energy could be targeted, and openness to change values could be strengthened. Energy conservation can also be achieved through targeting household energy consumption patterns. Our results suggest that it would not only be important to focus on financial measures, but that it is also important to enhance households' perceived possibilities to conserve energy, and to emphasize that households will not experience too much discomfort. This is important from a policy perspective, as the effectiveness of interventions aimed to encourage households to reduce their energy use may be enhanced when they target a broader set of theory-based psychological variables.

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Endnotes

1. Email: wokje.abrahamse@otago.ac.nz
2. 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.
3. Assumptions of the regression model were checked — and did not appear to be violated.
4. Socio-demographic and psychological variables were hardly correlated. We only found weak relationships between age and ascription of responsibility ($r = .14$, $p < .05$), perceived behavioral control ($r = -.17$, $p < .05$) and personal norm ($r = .25$, $p < .001$). Also, gender was weakly related to subjective norm ($r = .22$, $p < .01$). The other correlations were not significant (at $p < .05$).

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