Household energy requirement and value patterns[1]

Kees Vringer[a*], Theo Aalbers[a] and Kornelis Blok[b]

[a] Netherlands Environmental Assessment Agency (MNP), P.O. Box 303, 3720 AH Bilthoven, the Netherlands

[b] Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, the Netherlands

* Corresponding author. Tel.: +31 30 274 3816; fax: +31 30 274 4435.
E-mail address: kees.vringer@mnp.nl

Abstract

For an effective consumer energy policy it is important to know why some households require more energy than others. The aim of the study described here was to examine whether there is a relationship between the total household energy requirement, on one hand, and value patterns, the motivation to save energy or the problem perception of climate change, on the other. To examine these relationships we held a consumer survey among 2304 respondent households.

We did not find significant differences in the energy requirement of groups of households with different value patterns, taking into account the differences in the socio-economic situation of households. Only for the 'motivation to save energy' we did find that the least motivated group requires 10 GJ more energy than the average and most motivated groups; this is about 4% of the total household energy requirement.

This means that a self-regulating energy policy, solely based on a strategy of internalising environmental responsibility will not be effective in saving energy. There are indications that a social dilemma is one of the reasons why people's consumption patterns do not conform to their value patterns, problem perception or motivation to save energy.

Keywords: household consumption pattern, value patterns, motivation.

Introduction

To achieve a more sustainable energy system in the future, it is important to reduce or limit the energy requirement of society. Energy consumption cannot only be limited or reduced by improving the energy efficiency, but also by changing consumption patterns. The IPCC (2001) mentions change in consumption patterns as a possible response option to the treat of climate change, but the option of changing consumption patterns is insufficiently exposed. For an efficient consumer energy policy it is important to know how the energy requirement of consumption patterns is established and why some households require more energy than others.

In overviewing the consumption pattern in the Netherlands, Vringer and Blok (1995) found the net household income to be strongly related to the total (direct plus indirect) energy requirement. A wide range of other studies[2] also examined the energy requirement for consumption and found relationships between energy requirement and socio-economic characteristics such as income. However, differences in the household energy requirement cannot be solely explained by differences in socio-economic parameters such as income, household size and age. Households in a comparable socio-economic situation vary largely in the total energy requirement (Vringer et al., 1997).

The differences in the total household energy requirement are due to differences in consumer behaviour. There are many studies which use different theories and models to explain (parts of) consumer behaviour (see, for example, Steg and Buijs, 2004); Antonides and Van Raaij, 1997). These studies indicate that there are many factors influencing the actual consumer behaviour. One often mentioned factor is formed by people's values (Antonides and Van Raaij, 1997; Steg and Buijs, 2004; Nordlund and Garvill, 2002; Valette-Florence and Jolibert, 1990; Poortinga et al., 2004). Values can be defined as desirable goals that serve as guiding principles in people's lives (Steg and Buijs, 2004). According to Antonides and Van Raaij (1997) consumers use products and services (means) to realise desirable goals (values) like ambition, independency, comfort, freedom and pleasure. Valette-Florence and Jolibert (1990) analysed the relation between consumption patterns (measured as the purchasing frequency of 140 consumption categories) and values. They found a weak, but not negligible, influence from values on the consumption pattern, independent from socio-economic characteristics. Nordlund and Garvill (2002) quote many

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2 See e.g.: Lenzen, 1998; Biesiot and Noorman, 1999; Weber and Perrels, 2000; Munksgaard et al., 2000; Wier et al., 2001; Carlsson-Kanyama et al., 2002; Pachauri and Spreng, 2002; Lenzen et al., 2004; Pachauri, 2004; Cohen et al., 2005; Lenzen et al., 2006

studies in which relationships are confirmed between factors such as value orientation and specific pro-environmental behaviours like recycling and buying ecologically produced products. However, pro-environmental behaviour does not have to be relevant to the overall environmental pressure (see also Gatersleben et al., 2002; Stokes et al. 1994).

The emphasis in this analysis is on the relationship between value patterns and total energy requirement. We chose to examine two other non-socio-economic characteristics as well, which could be expected to influence behaviour more directly than values do. These were: (I) the motivation to save energy and (II) the perception of energy-related societal problems. Motivation is a central concept for consumer behaviour. Antonides and Van Raaij (1997) state that motivation activates and maintains certain behaviour; it also determines the direction and strength of this behaviour. So, if consumers are motivated to save energy, it can be expected that the more consumers are motivated, the less energy they will require. If consumers act as they think about societal problems, those who think that energy-related societal problems, such as climate change, are more important than other problems can be expected to use less energy.

The aim of this study is to examine whether there is a relationship between, on the one hand, the total household energy requirement and, on the other, value patterns, the motivation to save energy or the perception of energy-related societal problems.

In this paper, we first describe how we determined the value patterns of consumers and the household energy requirement. Next we examine the relationship between these, taking into account the socio-economic situation of the households. Finally we explore the influence of the perception of energy-related societal problems and the motivation to save energy on the total household energy requirement.

The consumer survey

To examine the relationship between the total household energy requirement, on one hand, and value patterns and the motivation to save energy or the perception of energy-related societal problems, on the other, we used consumer-specific information of 2304 respondents from the consumer survey (TNS-NIPO, 2003). The respondents filled in five different questionnaires; one for value patterns, two for the consumption patterns, one for their view on societal problems and

one for the "motivation to save energy"[3]. Not all 2304 respondents were asked to answer all five questionnaires. There were 2304 respondents who answered the questionnaires on value patterns and both consumption pattern questionnaires. Of these 2304 respondents, 1272 answered the questionnaire about the societal problem perception too and 935 answered the motivation questionnaire too.

To minimise the initial *non-response* we used a panel from the Dutch Institute for Public Opinion and Market Research (TNS-NIPO) for the consumer survey. TNS-NIPO took a random representative sample for Dutch households from a pool of about 80,000 respondents who were invited by TNS-NIPO to register for the panel. The response to our questionnaires was about 80%. After collecting the data we weighted the respondents according to net household income, size of the household, age and education of the breadwinner[4].

Determination of value patterns

The value patterns of consumers are determined according to the WIN-model[5] from TNS-NIPO (Hessing-Couvret and Reuling, 2002). The WIN-model is based on the value system of Rokeach (1973) and the work of Schwartz and Bilsky (1987).

According to Rokeach, in a value system values are ordered in priority of importance. A value is an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence. Rokeach distinguishes 36 values — all socially desirable — into two groups. One group contains 18 instrumental values (modes of conduct) and the other contains 18 terminal values (end states of existence) (see Table 1).

Schwartz and Bilsky (1987) found that seven motivational domains, taken from the literature, are organised relevant to one another and can be projected in a value space. Each domain contains a number of accompanying values belonging together (e.g. the motivational domain, 'security', includes values of inner harmony, family security, national security and a world at peace).

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3 The motivation questions were borrowed from an ECN questionnaire (see Kets et al., 2003).
4 In this study, the breadwinner is the person in the household with the highest personal income.
5 WIN = Values in the Netherlands (Waarden In Nederland).

Table 1   *The two lists of 18 values each, according to Rokeach (1973). One is with the instrumental values and one is with the terminal values.*

Instrumental values	Terminal values
(desired modes of conduct)	(desired end-states of existence)
1 Ambitious	1 A comfortable life
2 Broadminded	2 A sense of accomplishment
3 Capable	3 A world at peace
4 Cheerful	4 A world of beauty
5 Clean	5 An exciting life
6 Courageous	6 Equality
7 Forgiving	7 Family security
8 Helpful	8 Freedom
9 Honest	9 Happiness
10 Imaginative	10 Inner harmony
11 Independent	11 Mature love
12 Intellectual	12 National security
13 Logical	13 Pleasure
14 Loving	14 Salvation
15 Obedient	15 Self-respect
16 Polite	16 Social recognition
17 Responsible	17 True friendship
18 Self-controlled	18 Wisdom

For this study each respondent had to rank the two lists according to how important the values are for him/herself. The value space was transformed to two dimensions with the help of a principal component analysis (PRINCALS). Finally, Hessing-Couvret and Reuling (2002) made a cluster analysis for the respondents in the value space. They forced an eight-cluster solution and gave names to the clusters, based on the value occurring in each group and other known aspects (see Figure 1). In other words, the names mentioned in Figure 1 are not based on the perception of the respondents but refer to names taken from Hessing-Couvret and Reuling (2002).

Figure 1 shows the eight value groups in a two-dimensional space. One axis indicates a collective–individual dimension. Expectedly, consumers with a more individualistic value pattern like the Hedonists, Conservatives and Materialists are less focused on such societal problems as climate change than the consumers with a more collective value pattern such as the Broad-minded and Socially-minded. This makes it interesting to compare value groups of consumers with respect to their energy requirements.
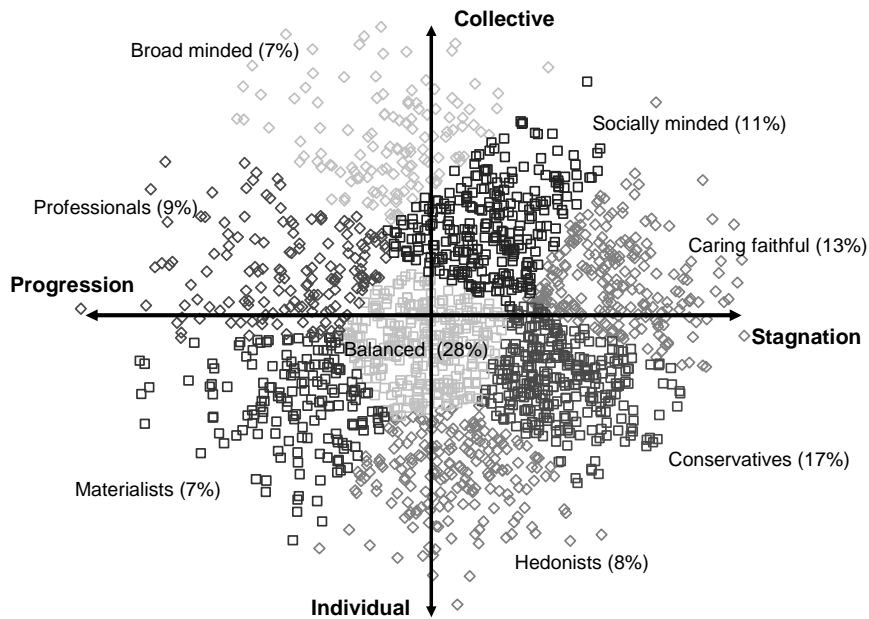
Figure 1   The eight value groups positioned in the value space, with two important axes (Hessing-Couvret and Reuling, 2002). The percentages reflect the size of the groups in the Dutch population, each tiny square representing one person.

Determination of the energy requirement

If the influence of value patterns, the perception of energy-related societal problems or the motivation to save energy on the total household energy requirement is to be explored, the actual total consumption pattern of a household and the accompanying energy requirement will have to be determined. We wanted to compare the actual energy consumption of a household with a reference; this is the average for households in the same socio-economic circumstances (see 'the *estimation of the standard consumption pattern*'). The determination of the actual consumption pattern and the calculation of the reference energy requirements are described below.

Determining the actual consumption pattern

The emphasis of the information provided by the respondents of the consumer survey is on the consumption categories demanding a considerable amount of energy or money. To avoid the conversion from monetary into physical terms, we collected the information mainly in physical terms. Because the expenditure

on durable consumer goods (e.g. cars) for individual consumers may peak in the survey year, we requested information on purchase and possession of these goods. Detailed information was requested on six groups of consumption categories: natural gas, electricity, transport, holidays abroad, the dwelling and food.

To determine the actual consumption pattern, we first made a standard consumption pattern and the accompanying energy requirement. This standard consumption pattern is solely based on the socio-economic situation of the households. We did this using the Household Expenditure Survey (CBS, 2002a). With the help of the detailed responses to our own survey, we adapted this standard consumption pattern to get the actual household energy requirement for the six groups of consumption categories using a method described below. These six groups of consumption categories collectively make up about 75% of the total energy requirement. Finally, the expenditures and accompanying energy requirement for the remaining consumption categories was established.

The estimation of the standard consumption pattern

The estimation of the standard consumption pattern and the accompanying energy requirement is based solely on the socio-economic situation of the households. To each household of the consumer survey, we coupled the average expenditure and the accompanying energy requirement of 350 consumption categories of the 10 most similar households from the *household expenditure survey* of 2000 (CBS, 2002a)[6]. To find the 10 most similar households from the expenditure survey, we characterised each household by a vector. We chose the 10 households from the expenditure survey, in which the difference in vector length between their vector and the vector of the household from the consumer survey is the smallest[7]. We based the vector on the socio-economic parameters that 'explain' most of the variance in the energy requirement for most consumption domains[8], using a regression tree analysis[9]. About 65% of the

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6   The household expenditure survey contains the expenditure of 2395 representative households in the Netherlands in 2000, divided into about 350 consumption categories. Vringer and Blok (1995) gave a detailed description of the survey. The figures of the household expenditure survey figures were adjusted for transport and direct energy requirement according to Vringer et al. (2001) and MONIT (2003). The energy requirement for each consumption category is calculated according to the method described in Vringer and Blok (1995) by using energy intensities for 1996 given by Kok et al. (2001). The energy intensities are indexed to 2000 on the basis of consumer price indexes according to CBS (2002b) and Erkens (2002).

7   In this analysis we chose 10 similar households to calculate the reference consumption pattern. We also made calculations for 5, 25 and 50 similar households. The results were comparable.

8   These are the nine domains used by Vringer et al. (2001), i.e. food, dwelling, housing, clothing, personal care, leisure outdoors, leisure indoors, holidays and labour. Note that the domains do not only consist of the products themselves, but also the required transport of these products from the shop to the dwelling, and the direct energy (natural gas, electricity) required to use these products.

variance in the energy requirement can be explained by all the socio-economic characteristics available in the expenditure survey. The net income is, by far, the most important factor in explaining the variance of the total household energy requirement (about 60%). We selected net income, age of the breadwinner, highest education of the breadwinner and household size[10], normalising these four dimensions[11]. We chose the weighting factors for the socio-economic variables of the vector to reflect the relative proportions of the separately 'explained' variance of the total energy requirement. The separately explained variances of the total energy requirement of net household income, household size, age and education are 62%, 36%, 15% and 7%, respectively. The difference in vector length between the vectors of two households is then calculated according to equation (1).

$$V^2 = a(I_{hes} - I_{cs})^2 + b(\text{Age}_{hes} - \text{Age}_{cs})^2 + c(HHs_{hes} - HHs_{cs})^2 + d(Ed_{hes} - Ed_{cs})^2 \quad (1)$$

In which:

V	=	weighted difference between the vectors of two households
I	=	normalised net household income
Ed	=	normalised highest education of the breadwinner
HHs	=	normalised household size, in number of persons
Age	=	normalised age of the breadwinner
hes	=	household expenditure survey
cs	=	consumer survey
a, b, c, d =		weighting factors of 0.51, 0.12, 0.30 and 0.06, respectively

The average consumption pattern according to the expenditure survey and the average standard consumption pattern calculated here are quite comparable. The differences between the expenditure survey of 2000 and the standard consumption pattern calculated here, vary per consumption domain from 2 to 14% of the expenditures and from 0 to 14% of the energy requirement.

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9 In a regression tree analysis the variance in the dependent variable (here, the energy requirement) is minimised by breaking up the data, using every possible binary split on every independent variable (here, many socio-economic parameters). The algorithm split the data into two parts by minimising the sum of the squared deviations from the mean in the separate parts. This splitting or partitioning is then applied to each of the new branches. We used a regression-tree model from S-PLUS.

10 For the consumption survey, comprising 52% men and 48% women, we took the breadwinner or his/her partner. Their ages were strongly correlated (R-square=0.84).

11 Each dimension is normalised by subtracting the average value from the actual value, and dividing this difference by the standard deviation of the value.

Natural gas and electricity

We asked the respondents about their payments to the energy companies, and which additional services were included in these payments, e.g. water, cable television and Internet. Next we asked the respondents how much kWh electricity and m^3 natural gas they had used in the past year, based on their most recent annual bill.

► Expenditures

We based the annual expenditure on the monthly payments to the energy companies as reported by the respondents[12]. If applicable, we subtracted the expenditures on additional services, based on average expenditures according to CBS (2002a) and CASEMA (2003). To split the combined bills into the shares for electricity and natural gas (85% of the households has a combined bill), we took the proportion of natural gas and electricity used as reported by the respondents. If the natural gas and electricity consumption in m^3 and kWh was unknown, we took the proportions of the standard consumption pattern.

► Energy use

Half the respondents knew their use of natural gas and electricity in kWh and m^3. For all other respondents for whom the physical use of gas, heating or electricity use was unknown[13], we established the energy requirement by using the expenditures on electricity and natural gas, minus the costs for the grid connections plus the eco-tax rebates (Van Maanen, 2003). The resulting expenditures and the kWh electricity and m^3 natural gas used were multiplied by the energy intensities (see Kok et al., 2001).

Transport

We asked the respondents how many cars they had, the type and age of the car and the annual distance travelled with this car for private use. We also asked how many kilometres they travelled between home and work and leisure and how they travelled for these purposes.

► Expenditures

We estimated the deprecation and maintenance costs of the car by taking into account its age, catalogue value and type[14]. We based the insurance costs and ownership tax of the car on the average insurance costs, according to the type of

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12 About 20% of the respondents had to make an estimation.

13 The energy requirement of households that use district heating or a central heating boiler (about 9%) could not be established unambiguously either.

14 For lease cars we took only the depreciation that could be assigned to the private use of the car.

the car (ANWB, 2003; Belastingdienst, 2003; Consumentenbond, 2003). The calculated fuel costs were based on the reported or estimated fuel use per km, type of fuel, the reported number of kilometres driven and the fuel price (CBS, 2003). The expenditures on train and/or bus were estimated using average distance travelled, the frequency and the bus and train fares (NS, 2003; GVU, 2003).

► Energy use

The energy requirement for fuel was calculated with the energy requirement per litre according to Wilting et al. (1999). The energy requirement for public transport, car maintenance and depreciation was calculated by using energy intensities from Kok et al. (2001).

Holidays abroad

We asked respondents who travelled abroad in the past year to tell us for each destination how they travelled and with how many persons. We also asked the kind and comfort level of the accommodation. We asked for detailed descriptions about the three longest holidays, assuming that the fourth and subsequent holidays would be equal to the third, or shortest, holiday.

► Expenditures

The expenditures on holidays abroad were based on the number of participating household members, duration, type and comfort level of the accommodation, mode of transport and destination (country or region). Fares for train, plane and boat were collected from Internet sites of several tour operators. Information on prices for accommodation as found on the Internet and brochures vary largely. Based on information from Aalbers (2004), we assumed an average price of 8 euro per person per night for a camping, 50 euro per night for a double room in a hotel and 450 euro per week for an apartment or holiday home. We indexed the (Dutch) prices for the different country regions with the Big-Mac index (The Economist, 2004) for luxury class accommodation[15].

► Energy use

The energy requirement for transport between home and final destination for holidays abroad was based on the energy requirement per kilometre (de Paauw, 1995; Essen et al., 2003). Where the car was used for holiday transport, we took the energy requirement per kilometre of the largest car. Extra fuel was taken into account for mobile home use. The energy requirement for the accommodation is

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15 We asked the respondents about the level of luxury of their accommodation. We assumed price differences from very simple, no star (-30%), simple, 1 star (-10%), average, 2 stars (0%), luxury, 3 stars (+20%) to very luxury, 4 or more stars (+40%).

based on the energy requirement per person/accommodation per night (see de Paauw, 1995).

Dwelling

We asked the respondents which type of dwelling they lived in and to tell us about the rent and several physical aspects of their dwelling (e.g. surface area of the living-room and number of rooms).

► Expenditures

About 40% of the respondents rent their dwelling, of which 88% knew their rent and 11% estimated it. About 1% did not really know how much rent they paid. For these respondents we took the expenditure and energy requirement according to the standard consumption pattern. To make a fair comparison with owner-occupants we calculated the rental value equivalent to the rent. To estimate the rental value for the remaining 60% owner-occupants, we used a model from Statistics Netherlands (CBS) to calculate the gross economic rental value (Sierman, 2003). To calculate the rental value of the dwelling, the model takes the type, age, size, region and a number of facilities like bath and type of heating into account.

► Energy use

The calculation of the energy requirement was based on the size and type of dwelling, according to the method used by Vringer and Blok (1993). We took into account the re-calculations made by Kok et al. (2001).

Food

We asked the respondents about their food consumption, for example, how often they cooked a warm meal at home, what type of meal they ate, what kind of meat they ate and how often they consumed fresh and/or conserved vegetables, and fruit & dairy products. This information is used to change the ratio between the food consumption categories, available from the standard consumption pattern. For example, the number of times a week a household enjoys dessert is assumed to affect the expenditure on custard and porridge. By calculating the expenditure and energy requirement on custard and porridge, we took into account the frequency of eating a desert. If a household consumes more desserts than average, the expenditure on custard and porridge is rised proportionally. The average expenditure on custard and porridge for all households is kept unchanged. Table 2 shows which information is known, and which consumption

categories this information is assumed to affect. More than 50% of the average expenditure on food is affected in this way.

Determining the actual consumption pattern

To establish the actual energy requirement of the actual consumption pattern, we took the estimated standard consumption pattern. We replaced the estimated expenditures and accompanying energy requirements of the six groups of consumption categories by the expenditures and accompanying energy requirement for the six categories, as calculated above. This results in the actual consumption pattern. This replacement resulted in an average rise in the total expenditure of about 5%[16]. For each respondent, we adjusted the expenditures and energy requirement for the remaining categories by multiplying the estimated expenditures and energy requirements for the remaining consumption categories by a factor to meet the initial expenditure plus the average rise of 5%[17]. On average, about 60% of all expenditures and 75% of the total household energy requirement is based on mainly physical information from the consumer survey.

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16   Possible causes of this average rise are the high price rise for natural gas and electricity between 2000 (expenditure survey) and 2003 (the year of the consumption survey) and underestimations of the expenditures for these six categories according to the expenditure survey, or overestimations according to the consumer survey.

17   Taking into account the dependency of the average rise with the net income.

Table 2   *Information from the consumer survey and the consumption categories affected.*

Known information from the consumer survey (TNS-NIPO, 2003)	Information assumed to affect the consumption category / categories	Number of consumption categories	Annual expenditure in euro$_{2000}$ per household *
Number of times per week:			
- dinner is cooked at home.	- directly related to ingredients for cooking warm meals at home	46	1008
- dinner is delivered or consumed as take-away, in a restaurant, canteen or	- directly related to restaurants and snack bars etc.	4	633
- no warm meal is consumed.	- kinds of bread and sandwich filling	9	587
- dessert is consumed.	- custard and porridge	1	76
- wine is consumed.	- wine	1	145
- Dutch food is consumed at home.	- potatoes	1	55
- Chinese / Indonesian food is consumed at home.	- rice	1	11
- Italian food is consumed at home.	- pasta	1	11
- fish is consumed.	- fresh fish and frozen fish	2	34
- meat is consumed.	- all types of meat	10	343
- poultry is consumed.	- poultry	1	77
- vegetarian food is consumed.	- eggs and cheese	2	203
- pork is consumed.	- bacon and fresh pork	2	105
- veal and beef are consumed.	- fresh beef and fresh veal	2	77
- ready-to eat food is consumed.	- main course dishes, frozen/canned	1	66
- frozen vegetables are consumed.	- frozen vegetables	1	11
- canned or bottled vegetables are consumed	- vegetables, canned or bottled	1	39
- fresh vegetables are consumed.	- all fresh vegetables	13	189
- ecologically grown fruit is consumed **.	- all fresh fruit	14	163
- ecologically grown vegetables are consumed **	- all fresh vegetables	13	198
- ecologically produced meat is consumed **	- all types of meat	10	342
- dairy products are consumed **.	- milk and yogurt	2	128

*   According to the standard consumption pattern.

** Only price differences between regular and ecological products are taken into account. We assume that ecologically grown vegetables are 25% more expensive, fruit 30% more expensive and meat 50% more expensive than traditionally grown vegetables, fruit and meat.

Calculating a reference energy requirement

To compare the energy requirement of a household with other households having the same socio-economic characteristics, we calculated a reference energy requirement. We based the reference energy requirement of a household on the socio-economic situation only. This reference energy requirement is chosen as, in most cases, the socio-economic situation cannot be easily changed by consumers themselves. We calculated the reference energy requirement using a multiple regression analysis. The four socio-economic variables which 'explain' most of the variance in the energy requirement (see above) are taken as independent variables[18]. The reference energy requirement can then be calculated according to equation (2).

$$E_{ref} = C + (a * I) + (b * HHs) + (d * Age) + (e * Ed) \qquad (2)$$

C	=	Constant
E_{ref}	=	Reference energy requirement
I	=	Net household income, in €
HHs	=	HouseHold size, in number of persons
Age	=	Age of the breadwinner
Ed	=	Highest education of the breadwinner, in education level
a, b, d, e	=	parameters, depending on the reference energy requirement

To calculate a reference energy requirement for the six groups of consumption categories and the total energy requirement, we carried out stepwise regression analyses. The results of these analyses are presented in Table 3.

The explained variance of the total energy requirement is about 62%, comparable with the explained variance of the household expenditure survey of 2000 (CBS, 2002a). The explained variance is relatively small for natural gas, electricity, transport, holidays abroad and dwelling.

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18   Wier et al (2001) found that power functions with elasticity coefficients describe better the dependence of the energy requirement on income than a linear function. However, adding an elasticity coefficient in the equation did not improve the models in this study. For calculating the reference energy requirement we chose for the most simple equation, so elasticity coefficients are left out the equation.

Table 3 *The factors resulting from the stepwise linear regression analyses required for equation (2) to calculate the reference energy requirements and the explained variance for each regression analysis (p<0.05, ns = not a significant contribution in Equation (2)).*

Reference energy requirement for:	Constant C	Factors a	b	d	e	Explained variance
- Natural gas	2007	0.32	4882	507	ns	0.11
- Electricity	10727	0.19	4682	100	-462	0.23
- Transport	57671	0.90	3489	-556	ns	0.10
- Holidays abroad	-4139	0.72	ns	ns	1703	0.09
- Dwelling	4244	0.05	624	35	114	0.18
- Food	-7775	0.71	2412	159	ns	0.56
- Remaining consumption categories	16921	2.41	-3081	ns	ns	0.59
Total	**46313**	**5.75**	**14853**	**471**	**ns**	**0.62**

Energy requirement and value patterns, motivation and problem perception

Next we examine the differences in the energy requirement, which can be related to the values of consumers, their problem perception of energy-related societal problems and their motivation to save energy. To examine the difference in energy requirement, resulting from differences in the perception of energy related societal problems, we took the problem perception of climate change. Each comparison was corrected for the socio-economic situation of the households.

Energy requirement and value patterns

The value groups with a more individually oriented value pattern, e.g. the Hedonists, Conservatives and Materialists, are expected to use more energy, considering their socio-economic situation. Figure 2 shows the average energy requirement for all eight value groups, including the standard error of the mean. Two energy requirements are given for each value group: (I) the reference energy requirement, which can be expected in view of the average socio-economic situation of the group of households, and (II) the energy requirement due to the actual consumption pattern.
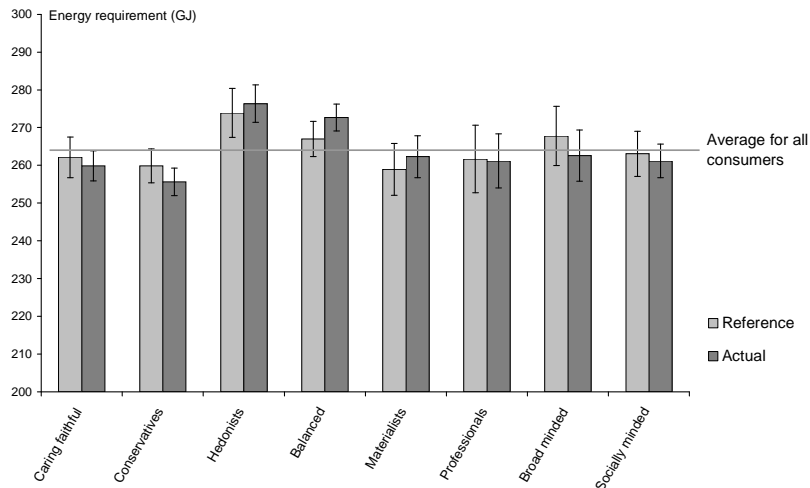
Figure 2   The total reference energy requirement and total actual energy requirement for the eight value groups, including the standard deviation of the mean[19]. Note that the vertical scale does not start at zero.

The differences between the total reference energy requirement and the total actual energy requirement are small; about 0 to 5 GJ (0-2% of the total energy requirement). To examine the significance of the differences between the reference energy requirement and the actual energy requirement, we calculated, for each respondent, the difference between the actual and reference energy requirement (ΔE). Figure 3 shows for the total energy requirement the average difference for each value group, including the standard error of the mean. A one-way ANOVA analysis[20] shows that the H0-hypothesis, "ΔE is equal for all value groups", cannot be rejected (95% significance level).

Next, we carried out the same analysis for each of the six groups of consumption categories of which the energy requirement is based on individual (mainly physical) information from the households, which are: natural gas, electricity, transport, holidays abroad, the dwelling and food (see Figure 4). Also we made an ANOVA analysis for the sum of those groups. The one-way ANOVA analyses for five of the six groups of consumption categories and the sum of these groups show that the H0- hypothesis, "ΔE is equal for all value groups", cannot be rejected (95% signifi-

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[19]   The standard deviation from the mean is calculated by dividing the standard deviation by the square root of N (here N varies between 190 and 497 depending on the value group). This implies that the error intervals in Figure 2 are equal to a reliability interval of about 67%.

20   One-Way ANOVA is a one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable. Analysis of variance is used to test the hypothesis that several means are equal (Van der Bercken and Voeten, 2002).
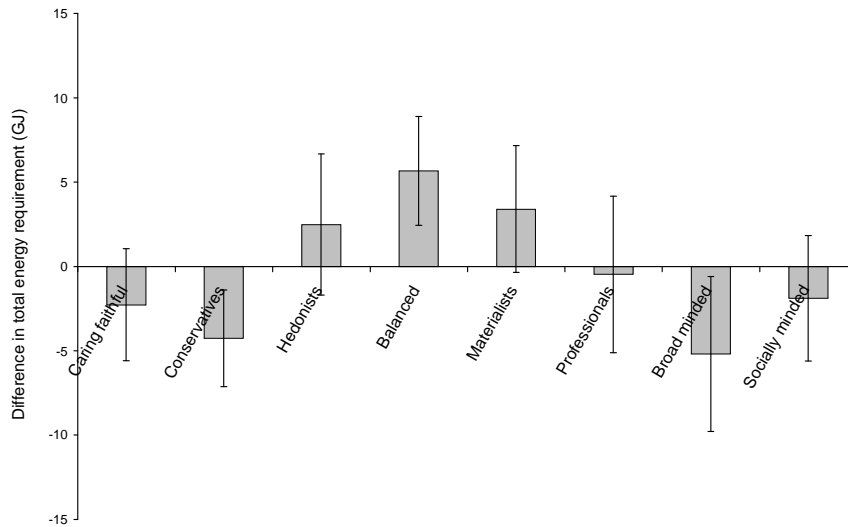
Figure 3   The difference between total reference and total actual energy requirement (ΔE) for the eight value groups, including the standard deviation of the mean.

cance level). Only for dwellings can the H0-hypothesis be rejected. It is assumable that for at least one value group ΔE for dwellings differs from the others. A closer analysis shows that the Materialists require about 0.7 GJ (7% of the average energy requirement for the dwelling) more energy than average.

Energy requirement and problem perception for climate change

To obtain the consumer's perception of the importance of the environmental problems, we asked the respondents to rank 16 environmental societal problems in order of importance[21]. We found that climate change was one of the highest ranked environmental problems. We divided the respondents into three groups, one ranking the problem of climate change low (7th in priority or below), one ranking the problem high (at 3rd place or higher) and one with an average problem perception for climate change (at 4th, 5th or 6th place). Figure 5 shows the total average energy requirement for the three levels of the perception of the climate change problem.

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21 The 16 environmental societal problems which had to be ranked are: (1) improvement in one's direct the living environment, (2) more nature in the Netherlands in future, (3) a better spatial organisation in the Netherlands in future, (4) fewer problems of noise in one's own neighbourhood, (5) no problems in the world of the future caused by the greenhouse effect, (6) no negative influence from genetically modified plants or animals on nature in the world of the future, (7) doing something about over-fertilisation in the Netherlands, (8) pre-existence of animals and plants by less deforestation worldwide in the future , (9) a decrease in the pollution of seas, rivers and lakes in the world of the future, (10) a better existence for the animals on Dutch cattle farms, (11) a decrease in air pollution in the Netherlands, (12) taking the environment into account in Dutch consumption, (13) cleaning polluted soil in the Netherlands, (14) raising the quality of public transport in the Netherlands, (15) more clean drinking water for developing countries in future, (16) reduction of the hole in the ozone layer in future. These 16 environmental societal problems were presented randomly to the respondents.
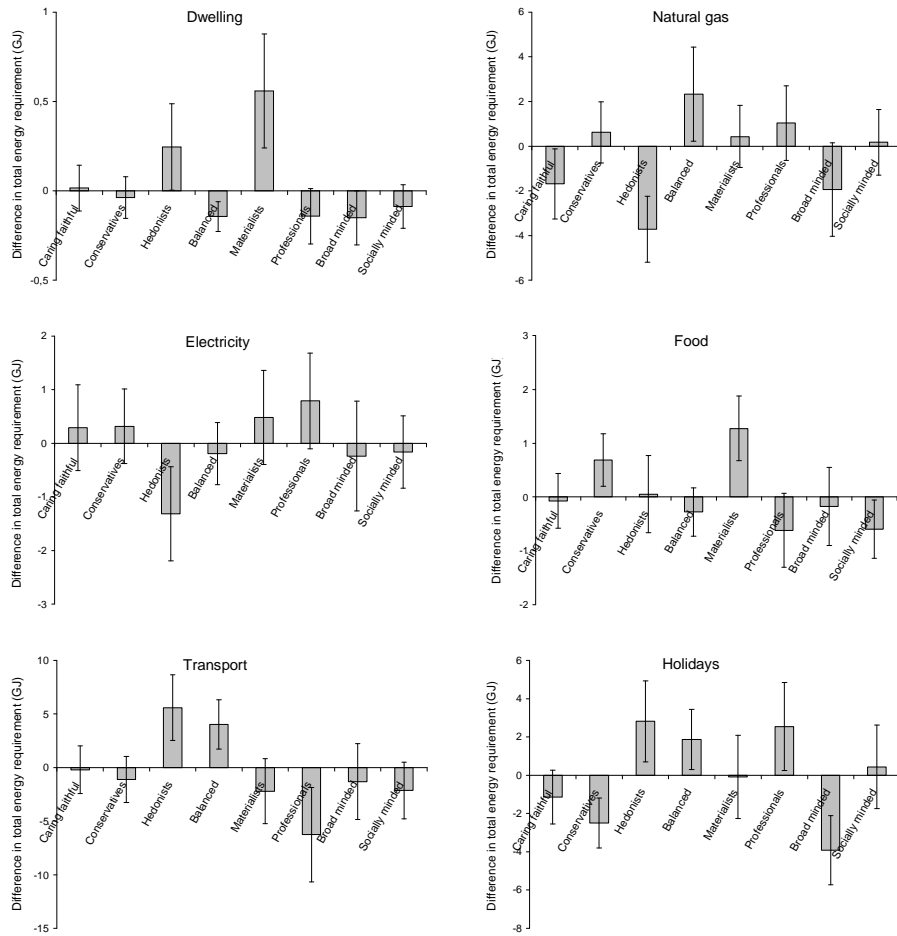
Figure 4   For all six groups of consumption categories the difference between reference and actual energy requirement (ΔE) for the eight value groups, including the standard deviation of the mean. Note that the vertical scales differ.

We expect that consumers who ranked the energy-related problem 'climate change' high would require less energy. The differences between the total reference energy requirement and the total actual energy requirement are small at about 0 to 2 GJ (0-1% of the total energy requirement). To examine the significance of the differences between the reference energy requirement and actual energy requirement, we calculated, for each respondent, the difference between the actual and reference energy requirement (ΔE). A one-way ANOVA analysis shows that the H0-hypothesis, "ΔE is equal for all problem perception levels", cannot be rejected (95%
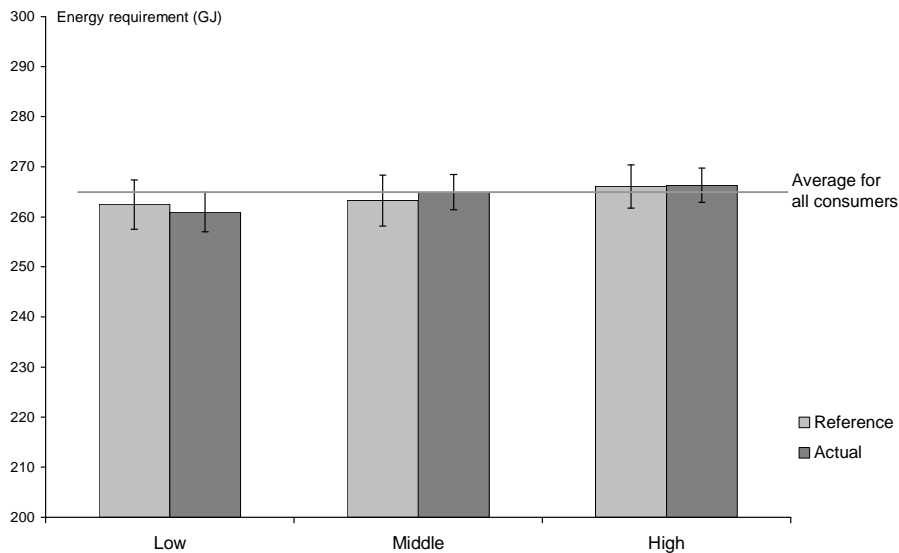
Figure 5   *The total reference and total actual energy requirement for all three problem perception levels for climate change, including the standard deviation of the mean*[22].

significance level). We found the same result for the energy requirement of the six groups of consumption categories: natural gas, electricity, transport, holidays abroad, dwelling, food, and the sum of those groups.

Energy requirement and the motivation to save energy

We used data from Kets et al. (2003) to examine the relationship between the energy requirement and the motivation of consumers. The respondents were asked to what extent they were willing to save energy on a 5-point scale, for nine different combinations of costs (higher, the same and less) and comfort (higher, the same and less). Hezemans (2005) made a one-dimensional scale from these nine combinations, which runs from a high willingness to save energy (willing to save energy, even though the costs are higher and the comfort is lower) to a low willingness to save energy (not willing to save energy even though the costs are less and the comfort is higher). We divided the respondents into three groups, one group with the least motivation, one with an average motivation and one with the most motivation to save energy[23]. Figure 6 shows the average energy requirement for all three groups.

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[22] N= 402 for the low, 344 for the middle and 526 for the high problem perception level group.

23 Most motivated: 33% of the respondents with the highest motivation level; least motivated: 33% of the respondents with the lowest motivation level; average motivated: 33% of the respondents between the highest and lowest motivation levels.
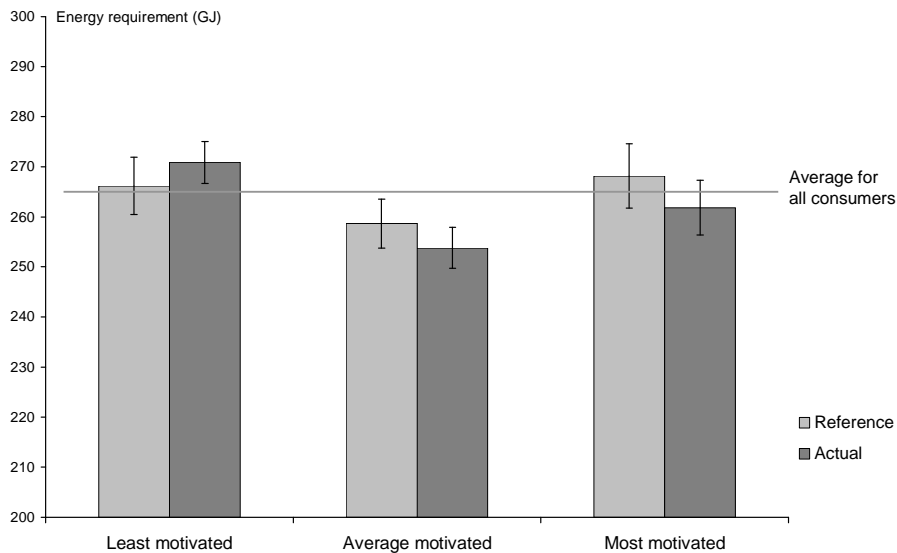
Figure 6   The total reference and total actual energy requirement for three different levels of motivation for saving energy, including the standard deviation of the mean[24].

We expect consumers highly motivated to save energy to require less energy. The differences between the total reference energy requirement and the total actual energy requirement are about 5 to 6 GJ (i.e. 2% of the total energy requirement). To examine the significance of the differences between the reference and actual energy requirement, we calculated the difference between the actual and reference energy requirement for each respondent (ΔE). A one-way ANOVA analysis shows that the H0-hypothesis can be rejected. It is assumable that for at least one motivation level group ΔE differs from the others (95% significance level). A closer analysis shows that the least motivated group requires about 10 GJ more than the average and most motivated group. Additional, we made one-way ANOVA analyses for the six groups of consumption categories, electricity, natural gas, transport, holidays abroad, dwelling, food, and for the sum of those groups. These analyses show that the H0-hypothesis, "ΔE is equal for all motivation levels", cannot be rejected (95% significance level)[25].

Conclusion

The one-way ANOVA analyses show that the difference between the actual and reference energy requirement (ΔE) is equal for nearly[26] all groups (95%

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24   N= about 310 for all the three groups.

25   This result is consistent with the findings of Hezemans (2005) for electricity.

26   There are two exceptions: 1) For the value group 'Materialists' is the energy requirement for dwellings about 0.7 GJ (7%) higher than expected (according to the socio-demographic situation). 2) For the total energy requirement, the least motivated group requires about 10 GJ (4%) more than the average and most motivated groups

significance level), taking into account the differences in the socio-economic situation of the households. The largest significant difference is found between the total energy requirement for the least motivated and average motivated group, which accounts for about 10 GJ or 4% of the total energy requirement.

Low- and high-energy households

As we have only found relatively small differences in the energy requirement that can be related to values, the perception of the societal problem of climate change or the motivation to save energy, there is still a large part of the variance in the total household energy requirement unexplained. To examine this unexplained variance here, we compare groups of households with either an extremely low or extremely high total household energy requirement. To define high- and low-energy households we first calculated the difference in energy requirement between the actual and the reference energy requirement. For each income-decile we defined a high-energy group (the 25% of the households with the highest actual energy requirement, compared with their reference energy requirement) and a low-energy group (the 25% of the households with the lowest energy requirement, compared with their reference energy requirement). We examined the differences between the low- and high-energy households, relating to the societal problem of climate change and the motivation of these households to save energy. As the net income is by far the most important parameter, we made the analyses for two income groups[27]. The average socio-economic situation does not differ within the same income group. We found only a small difference[28] in the urbanisation level; the low-energy households live in a less urbanised area than the high-energy households.

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27 We defined the low-income group as the 30% of households with the lowest net household income and the high-income group as the 30% of households with the highest net household income.

28 The urbanisation level differs about 0.5 level on a 5-level scale. This is equal to the difference between a strong and moderate level of urbanisation.
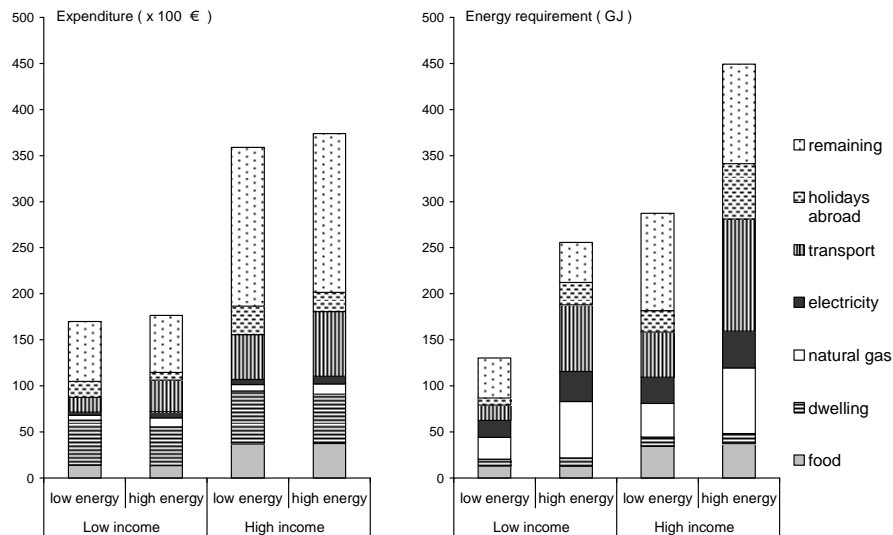
Figure 7 Expenditures and energy requirement for low- and high-energy and for low- and high-income households.

Figure 7 shows the expenditures and energy requirement for low- and high-energy households, and for low- and high-income groups. The high-energy households require 50% (high-income) to 100% (low-income) more energy than the low-energy households, while the expenditure is only about 4% higher for the high-energy households.

The high-energy households require two (high-income) to four times (low-income) more energy for *transport* than the low-energy households[29]. The low-income high-energy households more often have a car, while the high-income high-energy households more often have a second car. The high-energy households drive two (high-income) to four times (low-income) more kilometres and use the car more for commuting between home and work. The distance between home and work is about twice as large for the high-energy households as for the low-energy households. Besides commuting between home and work, the high-energy groups also use the car more for daytrips or nights out. More frequently, they motivate their use of the car as being more comfortable or mention a lack of alternatives in which costs are less important.

For *holidays* abroad the high-energy households require two (high-income) to three times (low-income) more energy. The high-energy households travelled about four times more than the low-energy ones. High-energy households require twice the energy of low-energy households for accommodation, while

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29 Remember that doubling the energy requirement for high-income households results in a higher energy requirement than quadrupling the energy requirement for the low-energy households.

their expenditure on this is 50% lower. Mobile home ownership is higher for the high-energy households.

The high-energy households require 10% (high-income) to 20% (low-income) more energy for the *dwelling*. The high-energy households more often own a dwelling which is relatively older, more often (semi-)detached and 10 to 15% larger.

High-energy households require 70% more energy for *natural gas and electricity* than low-energy households. They also have about 10% more kinds of electrical equipment and more energy-intensive equipment like electrical driers and dishwashers. No differences are found between the low- and high-energy households for the possession of energy-saving light bulbs (compact fluorescent lamps) and the purchase of 'green electricity'. However, most of the households, who report buying green electricity, motivate their choice with arguments that green electricity helps to diminish the greenhouse effect (60%) and benefits the environment (75%). This means that they are aware of the consequences of using energy.

In comparison with the low-energy households, the high-energy households do not require more energy for *food*.

The comparison of the low-energy households with the high-energy households did not result in significant differences in the order of importance of the two lists of the 18 values, nor the problem perception of climate change. The motivation to save energy differed slightly. We found a difference of 0.7 on a scale from 9 to 45 (see Hezemans, 2005). This difference is not significant (p=0.05). However, if this difference was significant and if motivation plays a role in saving energy, we expected a much larger difference for households using such a different amount of energy.

Discussion

We first discuss some of the aspects arising from the consumer survey and the calculated household energy requirement. This is followed by a discussion of the results.

The consumer survey
- Studies where the relationship between behaviour, on the one hand, and values, motivation, etcetera on the other, are examined with the help of surveys.

Socially acceptable answers may introduce a bias in the results. Social acceptability can play a role where respondents are ashamed to give an answer that is not socially acceptable. This effect is avoided as much as possible to guarantee anonymity to the respondents; besides they were allowed to fill in the questionnaires at home, without the presence of an interviewer. Furthermore, our questions were also divided over five separate questionnaires and the respondents did not know that the five questionnaires would be combined later on. The time between two questionnaires varied from two weeks to several months. It was impossible for the respondents to deduct our final research questions, which played the greatest role in the two questionnaires on consumption pattern. The absence of any relation between values, problem perception, motivation and total energy requirement (the actual behaviour) underlined that socially acceptable answers do not play any role in this study.

• The consumer survey contains *only data from the breadwinner* or her/his partner, while the consumption pattern concerns the whole household, where more persons can be active. In presenting the results, we implicitly assume that the value pattern, the problem perception of environmental problems and the motivation of the breadwinner or her/his the partner to save energy were comparable with the other household members. However, there is one group available in the dataset where this problem did not occur: the one-person households. For the one-person households we found results which are comparable with those for the whole population.

The calculated energy requirement

• To calculate the *reference energy requirements* we used a stepwise linear regression analysis. However, for some groups of consumption categories, the explained variance in the energy requirement is fairly small. An alternative reference for the energy requirement might give other results than obtained to date. In our additional analysis, where the standard consumption pattern based on comparable households was chosen as an alternative reference[30], the results of the additional analyses with the alternative references were comparable with the results we found earlier. This happened regardless of the number of similar households (5, 10, 25 or 50) we used to calculate this reference.

• In calculating the *actual total household energy requirement,* about 75% of the total energy requirement is based on individual information on consumption of the respondents. The remaining 25% of the energy requirement is estimated. The remaining consumption categories are based on the average expenditure and

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30 Disadvantage of taking the estimated consumption pattern as reference is that the estimated consumption pattern is based on only a few (5 to 50) similar households. We do not know whether all value patterns, levels of problem perception and levels of the motivation to save energy are equally distributed over the similar households.

energy requirement from the 10 most similar households taken from the household expenditure survey. Because we do not know whether the values, problem perception and motivation to save energy are equally distributed over these 10 households, we cannot draw any conclusions about a possible relation between the energy requirement due to the remaining consumption categories, on the one hand, and the value patterns, the motivation to save energy or the perception of the societal problem of climate change, on the other.

Results

- In their survey, based on just a few questions, Gatersleben et al. (2002) estimated the energy requirement of their respondent households. They also measured the level of pro-environmental behaviour of the respondents. Our results, based on a much more precise estimation of the household energy requirement, are in line with those of Gatersleben et al. (2002), who found that respondents indicating a more pro-environmental behaviour do not necessarily have a lower total energy requirement. Also Hezemans (2005) did not find any relationship between value patterns, the motivation to save energy and the use of electricity. Stokes et al. (2004) found that only a small percentage of people who whish to reduce their CO_2 emissions are really prepared or able to reduce their actual CO_2 emissions. The absence, or at most the presence of a weak relationship between values, problem perception, motivation and total energy requirement can be explained by the presence of a social dilemma. Antonides and Van Raaij (1997) mention the conflict between thinking in an environmental way and not doing so, due to a conflict between short-term individual interests and collective long-term interests. In the response to the consumer survey we observed that most of the respondents thought that not they, themselves, but others (with an emphasis on the public authorities), should come up with the solution to the most important societal problems, thus supporting the existence of a social dilemma. We also found that both the low- and the high-energy households from the consumer survey think that a climate policy should best be started without further delay. More research will be required to find out why people do not consume according to their values, problem perception, or motivation to save energy. However, this does not answer the question on why comparable households differ so much on their consumption patterns, with a large difference in total energy requirement as result.

Conclusions

Households in the same socio-economic situation can differ largely in their total energy requirement. Despite a detailed calculation of the energy requirement of

individual consumption patterns we could not find that the energy requirements of one of the groups examined for value patterns or problem perception level of climate change significantly differed from the rest, taking into account the differences in the socio-economic situation of households. Only for the motivation to save energy we did find that the difference between the total energy requirement for the least motivated and average motivated group, amounts about 10 GJ; this is about 4% of the total energy requirement.

We can conclude that the lack of a relation between the total household energy requirement and value patterns of consumers or their problem perception of climate change or their motivation to save energy, will mean that a self-regulating energy policy, solely based on a strategy of internalising environmental responsibility, will not be effective in saving energy. There are indications that the social dilemma is one of the reasons why people do not consume according to their value patterns, problem perception or motivation to save energy.

Acknowledgements

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