Energy and Households

The Acceptance of Energy Reduction Options in Relation to the Performance and Organisation of Household Activities

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Energy and Households

The Acceptance of Energy Reduction Options in Relation to the Performance and Organisation of Household Activities

De acceptatie van energie reductieopties in relatie tot de uitvoering en organisatie van huishoudelijke activiteiten

Diana E. Uitdenbogerd

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Foreword

My thesis is finally complete. The issue of energy use worldwide is challenging and exciting, and in the course of my research I have learned a great deal. I have read voraciously, participated in many conferences, and spoken to numbers of people. My objective was to show that when aiming for households to behave in an environmentally friendly manner, their behaviour and opportunities for change should be carefully examined in order to find better solutions. This will help both the environment and the households. During my quest for information and solutions, many people have inspired and supported me, both in the good years and in the years that were less so. First of all, thank you, Ans Groot-Marcus for your myriad roles, as initiator, household science conscience, and mediator, Paul Terpstra, thank your for being my promoter, and Bea Steenbekkers, for your thorough supervision and patience. I was always able to count on you. Thank you Henk Moll, for your special role as co-promotor, and Sanderine Nonhebel and Kees Vringer for telephone discussions and insights into energy issues. Scientifically, my time at Novem was very interesting, especially when Cees Egmond and I discussed the route to interventions for households. Our creative conversations are always a great pleasure. Cees, Gea, and Rea, thank you for the many warm visits, and the friendship. Ruud Trines, Frank Klinckenberg, and Bianca Oudshof, thank you for your faith in me. Nienke Brouwer, thank you for your comradeship during the first period of my thesis, when we did the food and textile case studies together, and while we ice-skated. Gerry van Nieuwenhoven, thanks for all the amiable chats, runs, and swimming sessions. Frits Antonijsen, Hester Moerbeek, Kees de Hoog, and Anke Niehof, you played essential roles in helping me to survive the research and writing process. Arianne Baanders, you also offered statistical suggestions at crucial times. Carja Butijn, Gerda Casimir and Hedy Munro, thank you for your unique views on all the topics we discussed. Riki van der Werf, Riet van de Westering, Dinie Verbeek and Margaret van Wissen, thank you for your practical support. Donna Devine, thank you for your conscientious work in editing the manuscript. Gerrit Antonides and Puk van Meegeren, you inspired me with regard to the clustering topic. Many friends supported me emotionally as well as scientifically, in particular Dolf Gielen and Keith Lovegrove, who showed me several parts of the world, and demonstrated that life is an adventure. Special thanks to Corestha Warmenhoven, you gracefully survived the endless phone calls about one chapter or another. Jan Tijssen, Yvonne Wooning, Robert Schuller, and Corina Dekkers, thank you for the interesting discussions. Miranda and Reino, and Ronald and Trish, thank you for being my friends for so long. Several 'support' groups were important as well. Hermien, Jacomijn, Suzanne, Maartje, Corestha, Annemarie and Simone, thank you for being there; I always look forward to our meetings. Joke, Annemiek, Anne Katrin, Joke, and Hera, thank you for your thorough intervision work and supportive insights. Eric and Ray, I visited you when I had just begun this PhD thesis, and again when I was nearly at the end of it. You have a special and warm place in my heart and in my parents' hearts as well. Thank you for somehow being my spiritual grandparents, and for my very special and safe start in life. Mam, pap, Martin, and Sandra, thank you for your ongoing support. Last but not least: a heartfelt Thank You to the households that participated in the surveys.

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'It is apparent that employed women wake up at about 6:30 on average or about 30 minutes before unemployed women do, although children in both types of household are awakened at about the same time (around 7:15). This means that employed women are able to undertake a variety of household activities before they need to deal with their children. Employed women wake up, make and drink coffee, start the dishwasher, groom, make lunch, clean the bathroom, dress, talk with their husbands, prepare and eat breakfast, and then awaken the children. The children are washed and dressed and given breakfast, and the breakfast things are cleaned up. The women then take their children to school or pre-school. The early morning hours are characterised by high levels of tension and anxiety. Anything that threatens to disrupt the necessarily tight sequence of activities will be a source of serious concern (Berk and Berk, 1979)'

1. Global Warming and Demand-Side Change

Anthropogenic greenhouse gas emissions substantially worsen the greenhouse effect. This effect is a natural process whereby gasses in the atmosphere absorb infrared radiation, and without which, temperatures on earth would be 30°C lower. In 2001 the Intergovernmental Panel on Climate Change (IPCC) concluded that 'studies of changes… indicate that there has been an anthropogenic influence on climate over the last 35 years' (IPCC, 2001); the Johannesburg Plan of Implementation (UNEP, 2002) even speaks of 'dangerous anthropogenic interference with the climate system'.

Increased concentrations of greenhouse gasses cause the atmosphere to retain more warmth than usual, which in turn leads to global and regional climate changes that can have devastating effects. Changes in temperature, winds, and precipitation will affect food production, ecosystems, river and sea currents, and the sea level. In northwest Europe, changes are expected in the direction of more precipitation (although with droughts in summer), changing temperatures, extreme weather events (including a higher number of storms on the North Sea), a rise in the level of the North Sea, and greater risks of flooding by rivers such as the Maas and the Rhine. In the Netherlands these changes will have consequences for agriculture (brackish or dried land), consumers and households (drinking water, electricity production), the industry (process and cooling water), inland shipping (navigability of the major rivers), and ecosystems (e.g. the Wadden Sea and biodiversity) (Uitvoeringsnota Klimaatbeleid, 1999).

Fossil fuel combustion is a major source of greenhouse gas emissions, and it is therefore important to lower energy requirements as well as the need for fossil fuels. However, although many reducing strategies address industries, transport sectors, and governmental bodies, the household sector is not given the same attention; its fragmented character seems relatively unimportant and difficult to address. Nevertheless, depending on the definition, the primary energy requirement of the household sector is about 20-30 percent of the Netherlands' total energy requirement. At the household level, for instance, Biesiot (1994) and Biesiot and Moll (1995) calculated that approximately 46 percent of the primary energy requirement of Dutch households is direct energy (through carriers such as electricity, gas, and so on) and 54 percent is indirect energy (used for the production, distribution and trade of goods and services). Since direct and indirect energy requirements are almost equal, this means that another 20-30 percent of the Dutch national direct energy requirement can be assigned to Dutch households in the form of indirect energy. In other words, households use 40-60 percent of the country's total (direct + indirect) energy requirement and even up to 70 percent when social services such as health care are included. As a result, energy reduction strategies should focus on both direct and indirect energy. Lowering indirect energy requirements can, for example, be accomplished by changing material use, reusing products or changing purchase patterns; lowering direct energy requirements can be achieved by efficiency improvements. Because households purchase numerous products, changing purchase patterns at the household level could be effective in gaining higher energy efficiency overall.

This thesis investigates whether energy-sound changes in household behaviour are possible. Household behaviour consists of, among other things, use and purchases that are related, respectively, to direct and indirect energy requirements. To change household energy consumption, a number of reduction options are needed; hence in this thesis it was investigated—within the household setting and from a household science perspective—which reduction options are available and acceptable.

This chapter presents the ins and outs of global warming, and explains the reasoning behind the research questions and why the study was conducted at the household level. The research structure is also described.

1.1 Global warming: factors, directions of action, and policies

Factors

As stated, energy requirement (e.r.) and fossil fuel combustion are important factors in the increasing greenhouse effect. Fossil fuel consumption is driven by direct (electricity, natural gas, gasoline, and so forth) and indirect (as needed for the production, transport, trade and waste treatment of goods and services) energy requirements. Other anthropogenic sources of greenhouse gasses are changes in land use (e.g. deforestation), agriculture (fertilisers, cattle, rice - NO_x, CH_4), burning of biomass (CO_2), and cement production. Depending on the type of greenhouse gas, the importance of these sources varies. Fossil fuel combustion is the major source of CO_2, the emissions of which, for a specific area and time, are generally calculated by the Kaya formula:

$$CO_2 = \text{population} * \text{income/capita} * \text{e.r./unit income} * CO_2\text{/unit e.r.}$$

CO_2 emissions are intrinsically linked to the population level, the average welfare level in income terms per capita, the average energy requirement, and the method and efficiency of providing the energy, which influences the CO_2 emissions per unit energy requirement (Kameronderzoek Klimaatverandering b, 1995, Bruggink).

The idea can be expressed in a more abstract way, which is often used as well:

$$I = P * A * T$$

In this equation, I = environmental impact, P = population level, A = affluence level (welfare in production and consumption per capita), and T = technology, which determines environmental impact per unit of production and consumption. These indicators are determined by the TEDIC complex: the interactions between and the developments in technology, economy, demography, institutions, and culture. These determinants are more suitable to address than are the indicators themselves. Although population level is important for environmental impact, affluence and the technologies in common use are of greater significance (Kameronderzoek Klimaatverandering b, 1995, Swart). An example of the combined effects of the indicators is as follows: despite its huge population and a high e.r./unit income (low energy efficiency), India has a relatively low CO_2 emission because of low income and low e.r./capita. It appears that emissions at first rise proportionally with income, but as the income grows the emissions increase more slowly. This can be explained by the increasing energy efficiency, by changes in economic structure (more services), and by changes in fuel mix: for instance, Switzerland has a low CO_2/unit e.r. because of low fossil fuel use (Kameronderzoek Klimaatverandering a, 1995). In addition, a negative correlation can be observed between fuel prices and per capita fuel consumption in countries of equivalent prosperity status. Despite what conventional wisdom from the industry suggests, energy prices appear to correlate positively, not negatively, with economic performance: low-cost-energy economies tend to be wasteful and uncompetitive, while high-cost-energy economies tend to be innovative and highly competitive (von Weizsäcker *et al.*, 1997).

The increasing direct energy requirements of European households since the 1970s was investigated by the IEA (IEA, 1997-2004), in whose member countries a significant part of the direct primary energy requirement (15-25 percent) was for the end user: namely, households. For comparison: the primary direct energy requirement of the travel sector was 15-25 percent as well. The other sectors were freight, services, and industry and manufacturing. Key indicators for the household sector were the increasing house area per capita, penetration of central heating (and appliance ownership), fuel mix, ratio of energy use for space heating to floor area (e.i. of heating), and the energy intensity of appliances. Drivers behind these indicators were higher standards for house space, decreasing household size, increasing central heating hours, penetration of CV installations, indoor air, and water temperatures and appliance use (IEA, 1997). In contrast, influences existed based on higher standards of building and insulation, on rising oil prices that influenced countries' energy policies and consequently the used fuel mix and energy prices in general, and the increasing efficiency of appliances. An increase in welfare could be recognised in all these factors. Indirect energy was not investigated as such in the past, but, as is explained in Chapter 2, an interaction exists between direct and indirect energy at the household level. Energy requirements for the consumption of goods and services are determined by the level of efficiency in production technology, by the economic structure, and by the culture of consumption that influences its quantity and composition. This aspect is discussed in Chapter 2.

Groot-Marcus and Scherhorn (1999) describe similar developments in influencing factors for direct energy in the Netherlands since World War II. On the basis of knowledge regarding the relation between health and hygiene, housing improvements became common and normative, and behavioural patterns were adapted. Developments included an increase in house size, connection to water, gas and electricity, extension of these systems throughout the house, and an improvement in the usability of the connection between these systems and appliances. The developments led to greater comfort and convenience, and this enhanced behavioural changes: home use decentralisation and a higher penetration of light and appliances, as well as increased use of the lights, the shower/bath, and the appliances. Despite the increasing growing costs, these developments have not been hampered, due to the positive economic climates; only the energy crises of the 1970s and lower economic growth in the 1980s have had an effect. Growing incomes, purchasing power, and welfare have also led to household dilution: Up to the 1970s houses had more residents that were not members of the core household but who now can afford to run separate households. This has also led to a relative increase in energy requirements per household.

Directions for action

In view of the above, what can be done? In accordance with the first formula, lowering CO_2/unit e.r. can be achieved through substituting fossil fuels with renewable energy sources or with fuels that are lower in carbon. Both CO_2/unit e.r. and e.r./unit income can be reduced through energy saving, which can be achieved by direct energy saving: improving technology and energy efficiency. When income is read as the equivalent of 'spending' or 'consumption', e.r./unit income can also be lowered by shifts in consumption. These shifts can be in material use, material efficiency, and a move to services instead of products and so on. The issue of population growth seldom emerges in the greenhouse debate, whereas it is generally agreed that on a global scale income/capita should grow. When income is read in terms of 'welfare', other criteria (except GNP) and related measures to improve income in an environmentally friendly way come to the fore.

It is said of environmental pollution in general that it decreases with economic growth and with more financial resources for rigid environmental policies and technology improvements in production. However, detailed studies by de Bruin (2000) have shown that this is not generally true and that it depends on time scales, system bounderies, and the subject under study. New and more efficient technologies will always lead to increased use as well, which results in the temporary unlinking of economic growth and pollution.

Notions about the relations between welfare, technology, and cultural and structural change are described by Midden and Bartels, Jelsma *et al.*, von Weizsäcker *et al.*, Te Riele *et al.* and Bruggink.

– Midden and Bartels concluded in 1994 that consumption serves general goals such as social recognition, control, safety, and variation. 'When consumption patterns are part of our cultural patterns, then it is something that we do ourselves and in principle something that can be changed'. In fact, cultural change can affect several levels of both societal and technological structure.

- According to Bruggink, structural changes in society, such as changes in family structure, time use, and consumption patterns are generally not given the attention they deserve (Kameronderzoek Klimaatverandering b, 1995) in the context of climate change. An example of a cultural change that led to structural changes in both society and technology was emancipation and the changed position of women, which led to more work hours outside the house and to the bearing of children at a later age. As a result more households have a double income and less time for household management. This again intensifies the trend towards an increasing penetration rate of appliances, and it changes the usage patterns and leads to more motorised mobility.
- Culture is also directly visible in 'scripts' in technology: expectations of use built into technology, which in turn reinforce behaviour (Jelsma *et al.*, 1998). This is not only true of technology at the level of appliances. Differences in culture at higher organisational levels and levels that are responsible for technical developments (fuel provision, transport systems, heating systems, spatial planning) also reinforce behaviour. A better use of resources that incorporate modern technologies (housing, heating, lighting, travel) can result in at least several advantages, including improved quality of life and less pollution and depletion. This can be attained by changing society's incentive structures, such as taxes, subsidies, information, and lower economic growth rates. All of these (seem to) give a return on investments for energy efficiency, which does not compete with other investments up to now (von Weizsäcker *et al.,* 1997).
- Te Riele *et al.* (2000) are also in search of 'transitions': steps beyond innovations or breaking trends in technology. According to the authors, changes in six areas are needed before a transition takes place: (1) material systems and products, (2) structures (politics, economy, society), (3) institutions (laws, agreements, co-operation strategies), (4) behaviour (practices, consumption patterns), (5) culture (norms, values, needs, ideas), and (6) intentions (science, skills). Bruggink (2000) states that humankind will have to accept that in addition to technical innovation a drastic reduction in greenhouse gas emissions depends on lifestyle innovation. He compares two developed countries, the U.S.A. and Japan, for which the balance between scarce resources and human preferences has been struck differently. The income level per capita in Japan is roughly 15 percent lower than in the U.S.A., whereas the energy use per capita is 50 percent lower. The major differences concern the residential and transportation sectors, not the industrial sectors. Partly the same technologies are used in a different way or in a different setting, and partly different technology systems are used. In a sense Japan has leapfrogged the American way of life.

In short, it can be said that leapfrogging is needed in order to reduce fossil fuel use and CO_2 emissions at the micro level and, consequently, in the long term at the macro level. The leap must be taken in the technology-developing sphere, in the cultural and the structural sphere, in the economy (supply and demand sides), and for direct as well as indirect energy requirements.

The inherent difficulty for either transitions or leapfrogging is of course that once structures are established they are relatively difficult to change. The Dutch policy on GHG emission reduction is described in the following section.

Policies

In accordance with the ***Kyoto Protocol*** (1997) the Netherlands agreed to diminish greenhouse gas emissions by 6 percent in the year 2012 compared to 1990 (Uitvoeringsnota Klimaatbeleid, 1999). This means an emission allowance of 200 Mton CO_2-equivalent per year in the period 2008-2012. This will be partly inside (220 Mton per year) and partly outside the Netherlands, with measures such as joint implementation and trade in emission quotas (100 Mton until 2012) (Tweede Evaluatienota, 2005). The package of national measures aims at a division of GHG emission reductions over CO_2 and other greenhouse gasses with a ratio of 70 percent CO_2 and 30 percent other greenhouse gasses. This is consistent with the present emissions: 78 percent CO_2 and 22 percent other greenhouse gasses. The reductions in CO_2 will be established by energy saving in all sectors, by an increase in the use of renewable energy sources, and by measures that diminish the carbon intensity of the fuel mix. This will be achieved by voluntary agreements with target groups, by legislation, and by support for investments through subsidies and positive taxes. Compared with the expected emission levels in 2010 (without measures) the target groups are expected to reduce emissions by 10 percent (Uitvoeringsnota Klimaatbeleid, 1999)[1].

For the mid-term, 10 percent durable energy in 2020 and an annual energy-saving percentage of 1.3 percent from 2008 and 1.5 percent from 2012 onwards is intended. In this regard plans are in place to develop measures, such as ambitious norms for appliances and vehicles as well as tradeable energy-saving certificates, which will lead to energy-saving measures: for example, in households (Tweede Evaluatienota Klimaatbeleid, 2005).

The Dutch long-term (50 years) policy has a six-theme approach to energy transitions:
(1) green raw materials, (2) sustainable mobility, (3) chain efficiency, (4) new gas, (5) sustainable electricity and (6) energy in the built environment. The aim is to lower emissions by 60-80 percent (Energierappport, 2005) to avoid environmental problems and to become less dependent on fossil fuels. Market, societal, and governmental organisations will work together to convert to a more sustainable energy consumption and supply. The aim is technological change, as well as a shift in attitudes relating to energy production and consumption, which will lead to different and new relations in society (Task Force Energietransitie, 2006).

The Dutch climate policy has had an effect: Emissions in the Netherlands were 5 percent lower (11 Mton) in 2003 than they would normally have been, and the industry and energy sector, the agricultural sector, and the mobility sector now emit less than the target amounts. Emissions in the built-environment sector and involving other greenhouse gasses are still too

[1] At the time of printing, Dutch energy policies, published in the Uitvoeringsnota Klimaatbeleid (1999) had been extended by way of the Energy Task Forces, but have otherwise not been changed.

high, although savings in the built-environment sector were among the highest (9 percent). Factors that can lead to unfavourable developments in the emissions are fuel prices and household-heating behaviour (Tweede Evaluatienota Klimaatbeleid, 2005). The recent growth in consumption, in particular mobility, is not compensated by technological improvements in the production industry (Milieubalans, 2006). The unlinking of economic growth and emissions is thus not stable and will decrease again with higher economic growth. It is expected that environmental targets for 2010 will be met; however unless the national policy is accompanied through international policy and cooperation there could be years of delay (Milieuverkenning, 2006).

In an analysis of the European and Dutch policies relating to energy, it is clear that many measures have been taken to improve direct energy efficiency and direct energy savings. Fewer *direct* energy requirements in one sector lead of course to fewer *indirect* energy requirements in another. However, scarce attention is paid to measures that concern indirect energy requirements, such as material efficiency, shifts in material use in the production sector, or shifts in consumption patterns on the demand side. Policy measures on the demand side with regard to indirect energy in the Uitvoeringsnota Klimaatbeleid (1999) have not been further developed (calculating emissions in the price of products; follow-ups of the Ecoteam and Project Perspective; supporting initiatives and experiments with energy-extensive products and services).

In view of the described examples, changes in the demand-side structures at the micro level are expected to support the achievement of long-term national targets at the macro level. Changes to the demand-side structures influence the factor *e.r./unit income* in the Kaya formula. As the magnitude of this support is not yet quantified, and because the micro level is difficult to address, it is no surprise that policy measures in this field have been neglected. As Nonhebel (2000) states: 'The household can be seen as the smallest metaphor for the consumption/production society of the Netherlands BV' (*i.e. 'incorporate'*). From the energy perspective, studying households is the best approach because nothing is overlooked, since households are at the end of the production/consumption chain. After all, nearly half of the Dutch energy requirement (direct/indirect) is used by households. To a large degree, individual consumers organised into households determine both directly and indirectly how many and what kinds of goods and services are produced, as well as the ways in which they are produced (Noorman and Schoot Uiterkamp, 1998). Thus, besides predicting the saving potential, a study of structural changes on the demand side might be indicative for changes on the supply side. Since the interrelations between structure, technology, culture, and welfare are present at the household level, it is useful to examine structural changes at the *household* level. Non-energy related reasons for studying changes in consumption structures at the household level are described in the following section.

1.2 Research perspective and research questions

Research perspective

A great deal has been achieved in technological solutions for direct energy saving, both on the production side and in the domestic sphere. However, history shows that the availability of new technologies, once introduced, promotes their use, and this increase in use nullifies the efficiency improvements for direct energy. Indirect energy is seldom a subject of research on behavioural change, regardless of the perspective, nor is the interaction between direct and indirect energy requirements in households. Research on changing consumption in order to save direct energy is often undertaken from a social-psychological perspective. However, many possible changes in activities or purchasing behaviour take place at the household and practical levels; hence in this thesis a household science perspective, household theories, and to a lesser extent the more traditional social-psychological perspective are used to investigate the acceptance of changes. The household science perspective structures and describes (effects of and on) households in relation to their environments. The acceptance of reduction options and the implications for energy-saving potential are investigated by including aspects of both household and behavioural change theories: practices, demographic variables, household production scales, environmental awareness, and so forth. Indications exist that after households implement a few energy-saving measures, they stop. However, the application of more than one reduction option—clustering—has seldom been investigated to date. Thus, possibilities for clustering reduction options in households have been explored here as well.

There are several reasons to study changes in behaviour at a household level and even to distinguish a functional and an organisational level. The environmental burden of households arises on a functional level: namely, the performing of activities related to household consumption and production. Therefore it is important to take into account actual household behaviour to do with consumption and production at a functional level. Further, it can be expected that implementing more than one reduction option requires organisational skills, which makes it relevant to consider the organisational level. In general the main reasons to consider the household level are:

- Consumption can be split and described in purchase and use patterns; indirect energy requirements can be influenced by changes in purchase patterns; and direct energy requirements can be influenced by (behavioural) use patterns. It can be expected that changes in purchase patterns generally influence the consumption patterns relating to a range of products. The same applies for patterns of use. In addition, purchases (indirect energy) and activities (direct energy) influence each other, especially within an activity category: for example, think of the purchase and preparation of frozen foods. Consequently, the feasibility of reduction options as well as the energy-saving potential is influenced by these interaction effects. Household purchases and activities can easily be studied in detail by examining the practical level; therefore the interaction effects can be studied as well;
- Shifts in consumption might also have consequences for household production, both directly and indirectly through the changing allocation of household resources: for

instance, time and money. Households can be considered non-profit enterprises, with the appropriate resources and activities to achieve goals. Goods and services are not only consumed but are also used by households to produce further goods and services. Changing both consumption and production within households and possibly changing the allocation of resources could endanger the achievement of a sufficient household care level. These consequences will not only directly influence the energy reduction potential but will also influence the acceptance, which indirectly affects the energy-reduction potential;

- Studying behaviour and consumption at the household level is different from studying consumers as individuals. Firstly, households function in a setting that includes several environments, such as societal, technical and physical, and economical and cultural. Secondly, most households still consist of more than one member, each with different standards, needs, and resources. A household deals with and is influenced by these environments as well as several internal and external social and organisational relations. Therefore, to speak about constraints, possibilities, and effects of energy-reduction options it is essential to take into account the group and the conditions in which household consumption and production takes place.

A household is more than just the sum of its members or the place where daily activities are organised. It is an organising principle of material and nonmaterial resources, of humans and their internal and external relations, and of consumption, production, and reproduction. It is an organisation within which routines and structure in relation to society are established in order for possibilities to arise for developments in welfare and well-being. A description of this nature makes one wonder whether it will ever be possible to ask households to engage in environmentally sound behaviour, given that this type of behaviour is not based in society. Modifying household behaviour in an environmentally sound direction must take into consideration the actual situation of households, their place in society, individual preferences and group processes, and the related complexity of strategies and activity patterns.

Research questions

A number of reduction options are needed to change household energy consumption. To evaluate the reduction potential of single and clustered reduction options, household practices are a good level to investigate; they provide the opportunity to reckon (in terms of MJs) with shifts in practices and to take into account interaction effects, changes in consumption and production, household member influences, and acceptance rates. In this thesis *household management* is defined a form of behaviour in which consumption and production (household activities) are organised and performed in order to meet the material needs and to create the material conditions for the nonmaterial needs of household members in their daily lives.

In short, it is expected that household management (practices, organisation) is relevant for an investigation of the acceptance and saving potential of reduction options. Hence, the overall question under investigation was:

(O) *What is the influence of household management (the performance and organisation of household activities) on the acceptance and energy-saving potential of greenhouse gas reduction options*?

The saving potential of (single) reduction options can be calculated on the basis of the theoretical potential, the percentage of households that accept the option, and the shift in actual practices of those households. The acceptance and saving potential of reduction options can be investigated per option and for preferred clusters, while the saving potential of reduction option clusters depends on the saving potential of single options as well as on the compatibility of the combinations.

Therefore the first research question was:

(1) *Taking into account the compatibility between reduction options, which technological and economically feasible reduction options for households are available for both direct and indirect energy requirements?*

As regards the saving potential for single options, both the practical level of household management and the acceptance of the options are critical. The relation between practices and acceptance provides an indication of the general inclination to change, and both can be influenced by several determinants. Therefore the second (three-part) research question was:

(2) *a. How are practices and willingness to accept single reduction options related?*
b. What are the determinants of the practices and the willingness to accept single reduction options at a functional level?
c. What is the relation between practices and the willingness to accept energy reduction options, when extended to an aggregated level?

As the purpose was to investigate consumption patterns, it was necessary to examine the acceptance and saving potential of a broader range of reduction options. From a household perspective, household management at an organisational level is important because options might not be compatible: for instance, technically, organisationally, or in preferences.
The households were first questioned about their practices and willingness to accept energy reduction options. A little later they received a summary of the first results of the survey, including background information about the energy reduction options; as a gesture of appreciation for their participation in the survey, the households also received payment in the form of a voucher. It is probable that, pursuant to the follow-up, a proportion of the households would perform the actions they had indicated as being acceptable. Thus, of the reduction options about which households were questioned and received information, it is useful to know which ones had either been considered or tried, and if the latter, whether the attempt was successful. Likewise, it is interesting to know whether a relation exists between the options that had been indicated earlier as acceptable and those that were eventually carried out, and, if such a relation does not exist or options were not carried out, whether there is evidence as to why the options were not carried out.

Therefore the following questions for a range of reduction options were formulated:

(3) *a. How are characteristics of household management at an organisational level related to practices and the willingness to accept reduction options?*
b. How many and which reduction options are accepted?
c. What are the determinants of the eventual acceptance of change?

The simultaneous acceptance of reduction options needs to be studied as well. The clustering of reduction options is a subject of investigation that led to the following research questions:

(4) *Is it possible to form a typology of reduction option clusters? If so, which reduction options make up these clusters?*

The search for clusters was done within the activity category Textile Care and for a broader range of reduction options. As well as these research questions, two issues were considered, mainly for the discussion. These were: (1) variety in practices and (2) possibilities to improve the nature of (clusters of) reduction options so that acceptance could increase.

- In section 2.3, reduction options are established—often on the basis of scarcely known and quantified practices—and the theoretical reduction potential is determined. However, the variety in performance and organisation of household activities can be such that unforeseen reduction options emerge during the investigation. Thus, the first explorative approach concerns the issue of variety in practices.
- Following an understanding of acceptance and the household setting's influence on acceptance, the second approach concerns the issue of how the nature of single or clustered reduction options can be improved in order to increase the domestic energy-saving potential.

1.3 Research structure

To answer the overall research question, it was first necessary to answer the underlying questions. In this section the research structure is described, as well as the reasons for setting it up in this manner.

The reduction options and the reduction potentials were determined (question 1). The single and clustered reduction options were later studied in two surveys. The main focus on single options (question 2) was in a case study, which concentrated on textile care and on six reduction options, but was also given attention in the general study. As preparation for the case study, a pre-survey was held. Question 3 focusses on the aggregated level of changes, which was mainly dealt with in the general survey. Clusters (question 4) were also addressed in the general survey. The general survey—which addressed 31 reduction options—consisted of three sections: (1) a written questionnaire, (2) for 50 households, a supplementary oral interview for additional understanding but which, for a variety of reasons, was not further analysed, and (3) a short follow-up survey to check actual changes in behaviour.

Pre-survey

An analysis of which practices and household characteristics are involved in the energy requirement for textile care as a preparation for the case study, could not be done with an examination of the literature; the information simply did not exist. Therefore, a pre-survey was held in 1997, as preparation for an in-depth investigation into the acceptance of reduction options in the case study. The behavioural context of textile care practices, ranging from shopping to discarding, was established, and aspects important for energy requirements were separated from less important ones. A rough division was made, for instance, of practices that involved shopping for clothing and other textiles, which led to more or to less laundry and that were related to the disposal of textiles.

Case study

The aim of the case study (1997) was to acquire information in a standardised way about specific fields of household activities and practices. To maximise the possibility of statistically significant results, the choice was restricted to one type of household, as it was expected that various types would have widely different practices. Households with children were chosen, as approximately 40 percent of Dutch households consist of family households (roughly 30 percent single and 30 percent couples). Therefore, the largest share of the population: that is, approximately 10 million people, lives in family households. In absolute terms, they consume most of the energy. Furthermore, it was expected that family households develope housekeeping strategies to cope with scarcity of time and money. Because information about practices as well as about acceptance was needed, oral interviews were conducted. The questions covered the practices within the activity category Textile Care that are related to the proposed reduction options. Notwithstanding the oral nature of the survey, questions about practices were asked as often as possible with quantitative answer categories. This made processing of the results possible, to quantify statistically significant relations as well as the domestic energy saving potential. Acceptance was asked about as often as possible in an open question because it was anticipated that the reasons for acceptance would be numerous and it would take up too much time and space to quantify reasons in pre-coded answers. In this way it was also possible to inquire in more detail about the acceptance of reduction options.

General survey

As with the case study, the general survey used quantitative questions as a basis to investigate the acceptance and energy-reduction potential of the *single* reduction options.

The general survey covered the acceptance of a broader range of reduction options (31). It included a mix of direct and indirect energy options; changes in purchase and housekeeping practices; large(r) investments and daily shopping. Focus areas were the house, transport, food, textile maintenance, holidays, use of appliances, and provision of energy.

Unlike the case study, the general survey was conducted in written form, with no open questions. As household organisation could be asked about in a reasonably straightforward manner, it was not difficult to formulate a questionnaire with quantitative questions.
For the clustering of reduction options, a specific question was developed that required households to choose (if possible) four options from a range of 31; in this manner they created their own clusters, which could result in a number of consistent clusters over the sample.

Follow-up survey

The general survey households that gave permission for ongoing research participated in a short quantitative follow-up survey, approximately a year later (April 2000). They received a summary of the results and information about reduction options in July 1999 shortly after the general survey (February-April 1999). The follow-up survey consisted of an overview of the 31 reduction options and briefly inquired into which of the behavioural changes had been carried out since the general survey and on the basis of the additional information in the summary. The purpose of the follow-up survey was to complete the logical line of surveys and to test whether acceptance of the reduction options investigated in the foregoing surveys was reflected in an actual change in behaviour.

1.4 Chapter lay out

The energy perspective is described in Chapter 2, and the economically and technically feasible energy-reduction options are described in more detail in Appendix 2D. Theories about household management, behavioural change, and reasons for acceptance are described in Chapter 3. Chapter 4 describes the case study and Chapter 5 the general survey and the follow-up survey. Conclusions and discussions are described in Chapter 6.

2. The Theoretical Energy Reduction Potential

One way to lower CO_2 emissions is to reduce direct and indirect household energy requirements. The first research question is addressed in this chapter, but before discussing which reduction options were the best choice, information on current direct and indirect energy requirements is needed. In §2.1 the hybrid analyses method is described, which was developed and used in the Lifestyle project (1990-1995) and the GreenHouse project (1995-2001) of the National Research Programmes on Global Air Pollution and Climate Change I and II. Project results that were relevant for this thesis are given as well. Criteria for the choice of reduction options are described in §2.2 and an overview of the reduction options used is provided. The calculations are described extensively in Appendix 2D. The analyses include the relation between the ways products are used as well as that between direct and indirect energy requirement. These relations are relevant if the feasibility of simultaneous changes in specific activity categories in households are analysed. The way to approach integrated energy reduction potentials is described in §2.3.

2.1 Energy research in the Lifestyle and GreenHouse projects

The method used in the Lifestyle and GreenHouse projects to determine the direct and indirect energy requirements associated with consumer expenditures was developed in the early 1990s. The hybrid method combines process analysis and input-output (IO) analysis in order to be fast and relatively accurate (van Engelenburg *et al.*, 1991; van Rossum and Wilting, 1991; van Engelenburg *et al.*, 1994; Wilting *et al.*, 1995; Vringer and Blok, 1995 b). The resulting data set has been made available by way of a computer programme (EAP) for storage and analyses (Wilting *et al.*, 1995; EAP, 1999). The total direct and indirect energy requirements of households in the Netherlands have been calculated using this data set in combination with consumer expenditure. The consumer expenditures were taken from the Netherlands Household Expenditure Survey. In this way, the energy requirement for 350 consumption categories, covering most of the household expenditures, was established.

The influence of the main determining variables, like income and household composition, have also been established. This has resulted in interesting differences between and within the main consumption categories. The total direct and indirect energy requirements of Dutch households have proven to be roughly of equal importance, a result that might hold true for most OECD countries. An attempt was also made to connect the differences in consumption patterns to lifestyle concepts, but this appears to have been fruitless (Vringer and Blok, 1995b; Biesiot and Moll, 1995). In the following, a short description is given of the hybrid method and the research results of the Lifestyle and GreenHouse projects[2].

[2] A recent update with 1996 household expenditure data showed only marginal differences in energy requirements (Kok *et al.*, 2006)

2.1.1 The hybrid analysis method and its application

The hybrid analysis method is based on process analysis, also called the energy life cycle analysis or energy analysis, and the input-output (IO) method.

The methodology of process analysis was established in the 1970s (IFIAS, 1975; Boustead and Hancock, 1979 in: Groot-Marcus *et al.*, 1996). In this methodology every process in the life cycle of a product is described and the quantitative relationships between these various processes are established. Subsequently, the energy consumption in each process within the life cycle is determined, and ultimately the energy needed for the life cycle of a product is able to be calculated: namely, the cumulative energy requirement of the product. In general, the cumulative energy requirement is expressed per physical unit of product (MJ/unit, MJ/kg or MJ/functional unit. The method for this energy LCA-like process analysis is relatively straightforward and is an accurate and exact method. However, determining the cumulative energy requirement (for instance, of consumption patterns) is laborious and incomplete, as there are numerous products and generally many processes or even process trees involved in the manufacture of products, which cause truncation errors in the analyses.

In an energy (IO) analysis the relationship between the various components of the product's life cycle are established, not on a physical basis but on a financial one, using the IO data and the energy intensity data of the economic sectors concerned. IO analysis uses tables in which the transactions between economic sectors are expressed in monetary terms. One result of energy IO analysis is the cumulative energy intensity of a production *sector* or of consumption *categories*. This intensity depicts the amount of direct and indirect primary energy that a sector needs per financial unit worth of supplies (MJ/currency). IO analysis is less accurate than process analysis, as no information on specific products can be obtained (e.g. dairy products but not semi-skimmed milk from a specific region). In IO analysis it is assumed that all products in a sector are produced in the same way: the homogeneity assumption. However, it provides the opportunity to calculate complete cycles and production systems or to estimate the energy requirements for remaining parts of a product's life cycle, because in IO analyses no truncation occurs (Wilting *et al.*, 1999; Nonhebel and Moll, 2001).
The hybrid method was developed to avoid the vast amount of work associated with the process analyses, and it integrates both above-mentioned methods. In the hybrid method the energy requirement of the most important processes in the product life cycle are analysed using the relatively exact method of process analysis. The energy consumption of the other processes and materials is estimated using IO analysis. In total, the hybrid method consists of eleven steps (summarised in Appendix 2A) and can be used for physical products, for relatively disaggregated product categories, and for services[3] to calculate the energy requirement (MJ/functional unit) as well as the energy intensity (MJ/currency).

[3] For a discussion on the indirect emission of non-CO_2 greenhouse gases, see Reinders and Blok, 1999; Nonhebel and Moll, 2001.

To estimate the energy requirement for the Dutch consumption pattern, the hybrid energy analysis method was applied to household expenditures obtained from national budget surveys (CBS, 1996), using the following general formula:

$$E = \Sigma^n \in_i . S_i$$

E = cumulative energy consumption of Dutch households
$\in$ = energy intensity (MJ/currency), calculated using the hybrid method
i = a desaggregated consumption category or specific product
S = expenditures in 'I' (currency), obtained from the national budget surveys

For a total of ten expenditure categories the results on energy requirement (e.r.), energy intensity (e.i.), and the yearly averaged expenditures of a Dutch household are shown in Figure 2.1.

As Figure 2.1 shows, the e.r. for Heating is high, followed by Food. The energy intensities differ for indirect energy (for more details see Table 2.1) and are high for direct energy: namely, Electricity, Heating, and Petrol. Expenditures are highest for the categories Food and Housing. The Housing category consists of expenditures for rent, maintenance, and garden, while the category Household effects consists of expenditures for furniture, upholstery, linen, appliances, and tools.

With the aim of saving energy in consumption patterns, it is useful to look more closely at the expenditures, at the energy intensities of expenditures, and at the final energy requirements in the aforementioned categories. All three direct energy categories are of interest because they relate to home use (heating, electricity) as well as to recreation and transport (petrol).

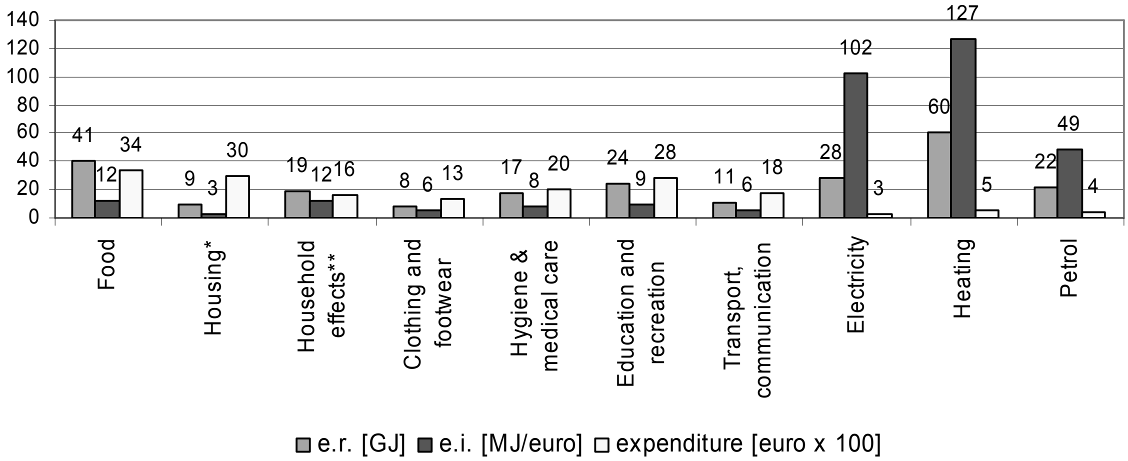

Figure 2.1 Recalculated energy requirements (e.r.) (GJ/hh.y), averaged energy intensities (e.i.) (MJ/euro[4]) of consumption categories, and the averaged yearly expenditures (euro x 100) of a Dutch household in 1990 (Biesiot and Moll, 1995)

[4] MJ/guilder converted to MJ/euro, 2.2 guilder = 1 euro

Within each consumption category the e.i. for separate products differs, as can be seen in Table 2.1. Products within the Food, Clothing, Transport, Personal Care (hygiene and medical care), and Education and Recreation categories are found in four of the five columns. Products in the House and Household effects categories are found in the three right-hand columns. The range of energy intensities within a consumption category can be a valuable starting point for lifestyle research and consequently for the differentiation of energy requirement.

On average the energy intensity for the total consumption package of Dutch households is 13.9 MJ/euro (Vringer and Blok, 1993); for direct energy carriers such as heating, electricity, and petrol it is 99 MJ/euro, and for the other main consumption categories it is 7.7 MJ/euro. It must be taken into account that a product can have a low or high energy intensity through a high or low price, respectively (Blok and Vringer, 1995).

Table 2.1 Distribution of products of classes of energy intensities (MJ/euro[2])

More then 50	18 - 50 MJ/euro	9 - 18 MJ/euro	4 - 9 MJ/euro	0 – 4 MJ/euro
Cheap detergents	Greenhouse veg.	Food products (sugar, fruits, bread, vegetables)	Food products (chocolate/ alcohol)	Take-away food
Gas and electricity	Conserved food	Meat (products)	Restaurants	Beverages outside
	Fats and oils	Care products	Insurance	Household help
	Frozen products	Newspapers	Mortgage	Rent, taxes
	Cheap meat	Stationery	Social services	Hairdresser etc.
	Plants and flowers	DIY products	Clothing, textiles	Smoking products
	Toilet paper	Medicines	Shoes	Tools
	Pet food	Furniture/linen	Books	Courses
	Alu foil	Holidays, pets	Education	Clothing
	Magazines	Public transport	Theatre tickets	Music/dance/sport
	Stamps		Cars	Appliances
	Gasoline			Taxi

Schmidt and Postma, 1999; Biesiot and Moll, 1995

2.1.2 Determinants in energy requirements and intensities

Studies within the Lifestyle project that have focussed on energy-differentiating lifestyles have implemented a definition of lifestyle in terms of the magnitude of expenditures and the distribution over consumption categories. The energy requirements of household consumption patterns are difficult to influence by factors such as income or household size; other determinants might be more relevant (Blok and Vringer, 1995). Results of studies on demographic variables and differences in consumption categories are described briefly below.

Demographic variables

Within the same income categories the spread in e.r. is between 68 and 140 percent compared to the mean e.r. The most significant deviation in e.r. is within the (somewhat luxurious) Recreation, Household effects, and Transport categories. As well as the variety within income classes, total e.r. depends on total *expenditures* in absolute terms. The relation of e.r. to income is not equal for all consumption categories: e.r. for Food, House, and Petrol rises slowly with increasing income, while for Household effects, Clothing, Electricity, and Transport it rises equally or more strongly compared with increasing income. As income grows, the price per physical unit of product can increase, as is shown to be the case for half of the consumption categories. In total, e.r. elasticity in relation to net household *income* is 0.6 and is smaller than expected (Vringer and Blok, 1997); e.r. elasticity related to *expenditures* is 0.8 (Blok and Vringer, 1995). Elasticities below 1.0 indicate price dissimilarities for different income categories[5], with a consequence for e.i. (assuming that higher priced products are made using the same amount of energy as lower priced products). The average price elasticity of all the food consumption categories is near zero (0.03) (Vringer and Blok, 1997). The average total energy intensity over all the expenditure categories has decreased from 16.1 MJ/euro to 12.1 MJ/euro when the net household income increased (Vringer and Blok, 1993).

An analysis by Blok and Vringer (1995) of different household types (young couples, elderly couples, young and older families, single elderly) has shown that within these groups (as a cross section) differences existed in the expenditures, mainly for Transport (with less spent on Food and Clothing) and Household effects (with less spent on Education and recreation). For household size and family stage (age) the relation to energy requirements is based on income differences. The difference between one-person and multi-person households is assigned to Food, Electricity, and Heating and Household effects (Biesiot and Moll, 1995). Another analysis (Vringer *et al.,* 1997) demonstrates that differences in education, age, and work participation can be neglected, whereas a higher urbanisation grade coincides with a lower e.r., due to smaller houses and less frequent possession of cars, and thus due to a lower direct

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[5] Apart from price differences, the results are not consistent for income and expenditures, because of savings and because not all expenditures were covered by the National Budget Survey (public services, taxes, school money, gifts). In addition, household expenditures were monitored for 2 weeks. Purchases normally made once a decade or so can distort the information in the data set (Blok and Vringer, 1995).

energy requirement. As a result of the diminishing household size (with 6 percent) the e.r. per person was 4 percent higher in 1995 compared to 1990 (Vringer *et al.*, 1997).

A Food category study has revealed three groups: one with high expenditures in outdoor consumption; one with high expenditures for beverages, fish, game, and other (soups, ready to eat meals); and one with low expenditures for these subcategories in combination with high expenditures for conventional food purchases (Schneider, 1994). A second study on food consumption patterns (Uitdenbogerd, 1995) has disclosed that certain household types have higher energy contents of +5-9 percent in the categories Other, Potatoes/Vegetables/Fruit, and Oils/Fats. A higher e.r. of +10-33 percent has been found mainly in products containing sugar (families and one-parent families). For younger singles a difference in e.r. of -45 percent has been found for meat and fish; for elderly couples a difference of -15 percent has been found for potatoes/vegetables/fruit. For the subcategories Bread and Milk products no differences in e.r. have been found between household types (Uitdenbogerd, 1995). A third study on food has demonstrated that in all segments, subgroups of households (with higher incomes) have been present with a high level of outdoor expenditures (Vringer *et al.*, 1997).

Despite the influence of difficult-to-change demographic variables, the e.r. variation within categories is larger compared to the total e.r., which is promising for lifestyle research (Blok and Vringer, 1995; Biesiot and Moll, 1995). These authors recommend analysing reduction alternatives in their functional setting, and they conclude that Transport is obviously a distinctive expenditure category (in both e.r. and expenditures), as well as Food (e.r. and expenditures), Education and recreation (e.r. and expenditures), Clothing (e.r.), and Household effects (e.r. and expenditures).

An experiment among households: project Perspectief

To determine whether changes in consumption patterns are feasible, 17 households living in new low-energy houses committed to an indirect energy reduction over a period of two years (1995-1997). For each household a level of energy consumption equal to that of a similar type of household with a 20 percent higher income was established. The task of each household was to save 40 percent of this e.r. level; to compensate for the expected general rise in income each household was allotted 20 percent more income as well. The households were assisted in making informed decisions. Named *Perspectief* (Perspective), this project was financed by the Netherlands Ministry of Housing, Spatial Planning, and the Environment. In total, 12 households composed of several family types met the commitment, with 43 percent (31 percent compared to the energy consumption related to their own income level), and maintained the low level of energy consumption for a year. The energy reduction was divided fairly equally over the seven consumption categories. However, while expenditures for Food and Housing increased notably, they decreased for direct energy requirements and for Education and recreation. After two years the households demonstrated a partial continuation of behavioural changes, with most success in the categories Vegetables and Recreation. For the subcategories Holidays, Beverages (sugar containing), and Furniture, not every household maintained behavioural changes. However, the use of electricity increased for most households

after the project had ended. The households were still satisfied with their new lifestyles; they felt it was gratifying to opt for quality and durability (de Weerdt *et al.*, 2000).
In accordance with Schmidt and Postma (1999), three strategies were used: diminishing (spending less), improving (spending more on better quality), and shifting (from products in one category to products in another category).

Although this project revealed no exact determinants, it showed in practice in which categories and with which strategies indirect energy saving is possible in the long term, even when income increases.

Developments over time

Between 1948 and 1996 energy requirements for consumption tripled. In this period no significant trends towards lower energy intensities were found and no dematerialisation of consumption patterns was indicated. In addition, indirect energy consumption per household decreased by about 10 percent, due partly to a decline in the number of persons per household. Changes in the structure of household expenditures played only a marginal role in the changes in indirect energy consumption (Wilting *et al.*, 1994). The same result was also found in another study, and it means that mainly 'more of the same' was purchased (Slob *et al.*, 1996). The use of petrol has increased the most, on average more than 8 percent annually over the past 40 years (Vringer and Blok, 1995; Vringer *et al.,* 1997).

It has been estimated that private expenditures will increase by 120-180 percent per person between 1995 and 2030 and that the energy requirement per person will increase by 30-60 percent (134 to 163 GJ/person) (Vringer *et al.*, 2001). It is forecast that by 2030 the energy intensity will be 40 percent lower, a decrease of 1.5 percent per year (7.1 MJ/euro), and by 2030 the total energy requirement of all Dutch inhabitants, including collective consumption, will have increased from 1927 GJ in 1995 to 3000-3400 GJ. This increase in the consumption volume is a consequence of social demographic factors, such as higher labour participation of women, older population, increasing education level, household dilution, and population and income growth (Vringer *et al.*, 2001). The reduction in energy intensity is due to autonomous efficiency improvements in household appliances (-12 percent) and in supplying sectors (-21 percent), as well as to a result of autonomous changes in consumption patterns (-15 percent). Striking is the relatively low increase in expenditures for space heating and mobility, causing the *direct* energy requirements to increase slower than the *indirect* energy requirement. From 1950 to 1996 the share of direct energy requirement increased from 35 to 50 percent. By 2030 this share will have decreased again to 33 percent (Vringer *et al.*, 2001).

A European comparison

An international comparison of consumption patterns can lead to the formulation of new reduction options. In the GreenHouse project two methods were used to do this.

The first method was to apply Dutch product energy intensities to household expenditure patterns in other countries (Nonhebel and Moll, 2001). This method was applied to household budget surveys in Belgium, Denmark, Greece, Spain, Italy, Luxembourg, The Netherlands, Portugal, Finland, Sweden, and the United Kingdom. In 1994 an average household required 274 GJ/year (Reinders *et al.*, 1999). The e.r. of the separate countries differed significantly from the averages: from -34 percent or 180 GJ/hh.y for Portugal to +85 percent or 508 GJ/hh.y for Luxembourg. The differences in total e.r. were due to differences in (1) population size, (2) expenditure levels, (3) share of direct energy requirement, partly because of climatic influences, and (4) differences in categories of indirect e.r. For example, in Portugal the share of direct energy was only 34 percent of the total, whereas in Sweden and Finland it amounted to 64 percent (Reinders *et al.*, 1999). It can be concluded that the energy requirements of Dutch consumption patterns are relatively low. Less money is spent on food, clothing, and housing than the EU average and more on recreation (and on direct energy, but this is a result of climate). This finding implies that within these categories few reduction options can be found abroad, since the neighbouring countries consume more (Nonhebel and Moll, 2001).

A similar result has been found with the second method, when IO analysis was used to establish the energy intensities of other countries' production sectors, and was applied to Denmark, France, Germany, Spain, Italy, and the United Kingdom. It appears that indirect energy requirements per household in these countries are lower than in Dutch households. In particular, the energy intensities of Dutch agriculture and industry are higher. Dutch households spend relatively little on meat, and only with regard to beverages and tobacco can the Dutch reduce in comparison to countries like France and Italy (Nonhebel and Moll, 2001).

Only Spain, Italy, Denmark, and the Netherlands were evaluated using both methods. In general it can be said that northern Europe employs more direct than indirect energy, while in the south it is the other way around, due to climate differences. It has also been shown that production energy intensities differ between countries. Energy production sectors ae more efficient in the Netherlands but the other production sectors (agriculture, industry) are more energy intensive.

Summary

The results of the above-mentioned studies can be summarised as follows:

- Between groups of consumers the determining factors that most strongly influence the energy requirement and/or energy intensity of consumption in the household sector are phase and composition, as well as the number of persons per household, urbanisation grade, and income level. Evidence is less clear for labour participation of women, age, and especially education. Age has an indirect influence through income level and the household phase. Differences in e.r. are visible between the categories Food, Electricity, Heating, Household effects, Clothing, Transport and Recreation. Differences with relation to several household types are found as well within the category Food. Despite the influence of demographic variables, the variation of the e.r. within categories is larger compared to the total e.r.
- The *Perspectief* project has demonstrated that shifts in consumption patterns are possible within groups of consumers or households. Significant differences were found in

expenditures for Transport, Petrol, and Car ownership. Slightly less significant were differences in Services, Personal care, Food, Clothing, Household effects, Education and recreation.

- Overall changes in society, such as population growth, household dilution, low cost of direct energy, income, and volume growth have led to an increase in the expenditure categories Transport (petrol), Electricity, House, Household effects, Education and recreation. This result has been despite developments like increasing efficiency and unlinking, and minor changes in consumption patterns. A rise in efficiency is expected in the future as well, leading to a decrease in the share of direct energy to 33 percent by 2030.
- Compared to other countries, the Dutch consumption pattern could stand to improve in the areas of Recreation, Agricultural products, Beverages, and Tobacco.

Not yet investigated are the steadfast acceptance of reduction options and the influence of regular household management on the relation between direct and indirect energy when changing household behaviour. In addition, clusters and the compatibility of reduction options need to be studied using larger samples representative for the Netherlands.

In any event, on the basis of these results and the suggestions by Blok and Vringer (1995) and Biesiot and Moll (1995), reduction options in the categories Recreation, Food, Household effects, Transport, Electricity, Heating (gas), and Clothing will be explored. The choice for energy reduction options is explained in the following section.

2.2 Criteria for the choice of reduction options

The hybrid analysis integrates with the household perspective in the product-use phase. This phase entails acquisition, use, treatment, maintenance, storage and disposal of the products and appliances, and services in and by the household. As depicted in Figure 2.1, direct energy requirements are high. The inclusion of reduction options for direct energy requirement makes it possible to have an impact on a larger scale because the theoretical energy saving potential increases. It was then possible to compare the acceptance of reduction options for direct and indirect energy requirements. Reduction options for indirect energy are fragmented and exist on low aggregated levels (see Table 2.1, e.g. the energy requirements for food products). Investigation of this acceptance would have relatively laborious compared to the theoretical saving potential. Another reason to include direct energy options is because an interaction often exist between direct and indirect energy requirements, depending on the character of the reduction options. This interaction could affect materials, appliances, activities, and processes in the household or within the context of the household, which could have consequences for the eventual energy-saving potential as well. Doing laundry at lower temperatures, for example, could lead to more frequent washing, to more use of detergents, and to the purchase of a tumble dryer and different clothing materials.

By examining activities, direct and indirect energy requirements *and* their interaction are tackled simultaneously. These activities are able to take place within domains of household activities such as textile care, food provision, recreation, and personal care. Studying reduction options per activity category prevents burden shifting. Through the related practices and activities, changes in household consumption within an activity category are likely to have consequences for the use of other products or for the consumption of direct energy (Nonhebel and Moll, 2001).

Reduction options were chosen on the basis of the following:
- their energy-saving potential, at least 0.5 GJ, taking into account both indirect and direct energy;
- the relation between direct/indirect energy reduction options in the use situation;
- the chain of relations and interaction effects in the use situation;
- as far as possible an equal number of options related to use, activities, and practices on the one hand, and to investments and purchases on the other;
- that options involved current technology and were readily available for households;
- results of the Lifestyle and GreenHouse projects desk studies as mentioned in §2.1, including Food, Clothing and Textile care, Housing effects, and Recreation; and for direct energy, Electricity, Heating, and Transport.

The chosen reduction option and categories are shown in Table 2.2.

The categories (car use, use of washing machine/dryer, holidays, alternatives for textile materials, alternatives for appliances, floor covering, flowers, meat and vegetables) consisted of more than one option. A choice such as alternatives for appliances consisted of a gas-fired dryer, space for laundry drying, and the most efficient tumble dryer. Options that consisted of one alternative and are mentioned in the table as such were: heating less, wash temperature, pre-rinsing dishes, longer use of textiles, energy-saving light bulbs, solar boilers, green electricity, and water-saving shower heads. The 18 categories encompassed a total of 31 reduction options.

To determine which technological and economically feasible reduction options were available for both direct and indirect energy, the reduction potentials of the options were estimated using diverse methods, with either national expenditure averages, national usage averages, or per application. For a description of the estimation methods, the assumptions, and the potentials of the reduction options see Appendix 2C and 2D. The options were related to nearly 75 percent (176 GJ/hh.y) of the total household energy consumption (240 GJ/y).

Table 2.2 Reduction option and categories investigated

	Use/activities/practices	Investments/purchases
Direct energy requirement	Heating Car use Wash temperature** Use of washing machine/dryer** Pre-rinsing dishes**	Energy-saving light bulbs Solar boiler Green electricity Water-saving shower head Alternatives for appliances**
Indirect energy requirement	Holidays Use of textiles** Textile materials*	Floor covering Flowers Meat (substitution, vegetarian)** Vegetables**

** investigated in the case study; ** investigated in the case study and the general survey*

2.3 Energy reduction potentials

Integrated theoretical energy reduction potential

If more than one reduction option is simultaneously applied, the options can influence their mutual energy-saving potential, either directly or indirectly through the use context. Therefore, compatibility must be taken into account. The integrated reduction potential stands for the potential of several options after considering interactions involving energy or use level.

Within the GreenHouse project the integrated result for the Netherlands of 44 reduction options was calculated using an elaborated IO method and a homogeneous IO table that distinguished 246 product groups (Wilting *et al.*, 1999). The 44 *individual* options added up to a reduction potential of 32 percent, whereas the *integrated* result was 27 percent (27/32=0.84). It is probably safe to say that in general a factor of 0.8-0.85 can be used to estimate integrated energy savings. As well as the demand-side options, supply-side reduction options led to another 30 percent reduction: altogether 54 percent on a national scale (Nonhebel and Moll, 2001; Wilting *et al.*, 1999). It is noteworthy that of this set of 44 demand-side reduction options, 20 were used for this thesis as well.

For the 18 categories of reduction options mentioned in Table 2.3, a matrix was constructed to initially assess compatibility or direct interactions in energy terms (Appendix 2B). The total savings based on the diverse calculation methods used for Appendices 2C and 2D were 17 percent (40 GJ) of the total household energy requirement. This did not include a solar boiler, smaller washing machine, gas-fired dryer, not having a car, and not using a tumble dryer, as they were not compatible with several of the other options. Including these options would have led to a further 13 percent (30 GJ) reduction: 70 GJ in total. However, because other reduction options were affected, this reduction potential was estimated to be 26 percent (63 GJ), using a factor of .85 and rounding off. The affected options were rinsing of dishes, water-saving shower heads, sharing a car, using a lighter car, full washing machine loads, full dryer loads, selective use of the dryer, most efficient dryer, and spin-drying.

As well as an interaction in energy terms, there can be an interaction by means of practice changes that indirectly influence energy requirements. The estimated interactions are indicated by a dot in the Appendix 2B matrix. An interaction in practices can, for example, be the effect of heating differently or of pre-rinsing dishes. However, interactions of this nature have not yet been studied, so it is difficult to predict the consequences for energy requirements.

Single reduction options saving potential

Aside from influences and interaction in energy terms that might lower the energy-saving possibility, the potential is also influenced when acceptance is taken into account. The Domestic Energy Saving Potential (DESP) is used as a means to predict the eventual reduction potential of individual options. DESP is calculated using three elements: ETP, A, and Δ(DAP) (see the formula below). The Economic and Technical Potential (ETP) is a standard abbreviation for a reduction option that is economically and technically possible. *A* stands for the percentage of households willing to change and to take up the reduction option; *Δ(DAP)* stands for the magnitude of change and is basically a shift towards more households behaving in a more energy-conscious manner. This change is either quantified and weighted by an assumption based on actual practices or is indicated by the willing households themselves.

$$\text{DESP} = f(\text{ETP}, \text{A}, \Delta(\text{DAP}))$$
$$\text{or: ETP} * \text{A} * \Delta(\text{DAP})$$

DESP = domestic energy-saving potential (MJ/hh.y)
ETP = economic and technical potential (MJ/hh.y)
A = acceptance in percent of willing households
Δ(DAP) = shifts based on actual domestic practice (DAP), calculated as: new situation/old situation

This approach results in a prediction of energy-saving potentials that is more quantitative than either assuming willingness and calculating with exact figures at the household level in a desk study or measuring willingness empirically and calculating using national averages. To achieve a satisfactory result from this approach it is important to do the following:

- calculate at the household level and do not to work with averages;
- at a household level, measure empirically both the willingness to change as well as actual practices or the actual situation;
- monitor the willing group on their actual practices and base an assumption of shifts either on groups that already perform the activity in a more energy-sound manner or on estimations provided by the group itself.

Further, it can be said of this approach that:

- it is a combination of a technical -, social scientific-, and energy research approach;

- it will often show, because of the measurement of activities, that information on domestic energy use based on ETP cannot be applied unequivocally;
- it can be used to predict quantitatively which options are feasible for certain groups of users and which are worthwhile: for example, to add to an energy-saving campaign;
- although not a watertight method because of the qualitative measurement of willingness to change, the order of magnitude of prediction will probably be ±10 percent. However, the only way to test this is to combine the DESP approach with an experiment.

Saving potential of clustered reduction options

If the DESP formula is valid for one reduction option, the following equation is then valid for clusters of reduction options:

$$DESP_{cluster} = f\ (ETP_{cluster}, A_{cluster}, \Delta DAP_{cluster})$$

However, the question is how to relate and to calculate the elements on the right-hand side of the equation. For independent reduction options, or for reduction option in different domains, the reduction potential can be added. Within domains, the ETP of interacting options can be assumed to be lower than the added potentials, and for efficiency measures in heating it is usually calculated with a factor $(1-\delta_1.\delta_2)$, for which δ is a reduction factor (Moll, 2003; EPA, 2002).

It can be expected that in many instances relations exist not only in energy terms but also in practices and in acceptance. However, calculations would necessitate numerous equations, factors, and so on, and a system analysis that was not an objective of this study. In general it can be said that the technical integration leads to a reduction of approximately 15-20 percent in energy saving (thus without taking into account acceptance or shifts in practices).

3. Behavioural Change from a Household Perspective

In this chapter, perspectives, theories, and concepts are described that are used to investigate the acceptance of energy reduction options and the influence of household management on this acceptance. The essence of households, the paradigms and the scope of household sciences, and an elaboration of the household science perspective are also provided. Factors are then described that must be taken into account when changing household behaviour.

3.1 Introduction

Studies on energy conservation and behavioural change with regard to energy saving began in the early 1970s when oil prices rose. At first, theoretical models were seldom employed. Research was restricted to inventories of relevant behaviour in relation to monitoring energy requirements, although research on attitudes was not uncommon and was applied in environmental psychology (relating to surroundings) and in social psychology at the beginning of this century (Thomas and Znaniecki, 1918; Allport, 1935). Along with the growth of research on the public's perception of the energy crisis, conducted from the social-psychological perspective, other attitudinal factors that might determine or contribute to energy-conserving behaviour were examined. In practice, in the 1970s the focus for change was directed at influencing the *general attitude* towards the environment by providing information. New insights in the 1980s led to a strong focus on *specific* environment-related *actions* in order to change behaviour. Frequently investigated behaviours involved, for instance, choices about large investments such as insulation and smaller investments such as draught-proofing, water-saving showerheads, and the purchase of daily necessities. Conservation routines (for example, to save water or to separate waste) were investigated as well. However, up until now the acceptance of environmentally friendly innovations has been studied to a lesser extent. Strategies to achieve changes in daily behaviour include prompting, modelling, specific information, and personal feedback. In campaigns relating to specific actions too little attention has been paid to the need to change behaviour on a larger scale (Beck *et al.*, 1980; van Meegeren and van Woerkum, 1994). In the Netherlands it is presently being investigated as to whether changes in the social environment can have an effect, and whether strategies to accomplish this, as well as ones that concentrate on the individual, can be scaled up to a national level (Herben, 2002; Kok *et al.*, 2007). The use of the social-psychological perspective in research on energy conservation and behavioural change has remained unchanged.

Compared to behavioural changes in individuals, the influence of household organisation and the actual performance of functional activities are less often investigated[6]. Poorly represented aspects include the interaction of household members with one another and with technology; the influence of the household situation and actual practices on the acceptance of change; the

[6] See for example the literature reviews of McDougall *et al.* (1981), Lutzenhiser (1993), and Kok *et al.* (2007).

relative importance of norms for household management compared to norms for environmentally friendly behaviour; and the acceptance of different changes simultaneously.

Hofstee (1972) has described how environmental problems can be approached. He considers that realising the provision in human needs, and the function of society in this provision, is closely related to environmental problems, thus making the functional approach a suitable starting point. To explore environmental problems more deeply, a structural and a cultural approach are also needed, because these problems have a cultural/structural component as well.

The functional household science perspective was chosen because energy use and energy saving take place at the functional activity level, and this approach can take into account the aforementioned, less represented aspects of environmentally relevant household behaviour.

The following section highlights the history of household sciences[7]. The third section continues with the functional approach, which is elaborated upon in the fourth section. The fifth section relates the household perspective to an individual behaviour perspective, and the sixth section describes how these points of view are applied in the surveys.

3.2 History of household science perspectives

3.2.1 Views of Aristotle and Xenophon

The earliest author known to have written about households was Aristotle (384-322 BC). In *Ethics* and Book I of *Politics* he wrote about *oikonomia*: household management. The *polis*, the society in the city-state, was a compound of villages and households, and *Ethics* was the practical science of good behaviour, where 'good' refers to happiness as an activity of the soul in accordance with virtue (Aristotle, 1976, 1992). *Economics* was intended to create an optimal system for people to live together on a daily and a micro scale, whereas *Politics* was meant to create the best system for people to live together on a macro level (East, 1980). Thus, according to C. Presvelou, a Greek professor in household sciences in the Netherlands, Aristotle had a profound insight into the relationship between *oikos* and *polis*, between home economics, economics, and politics (Presvelou, 1980), and between happiness, daily life, and society as a whole.

Egner (1985), a renowned German home economist, also refers to Aristotle: 'The central focus of Aristotle is the living together of people in the community (*koinonÍa*) as well as in the house and in the society. Both depend naturally on self-sufficiency (*autarkeÍa*), which can be derived from the traditionally determined needs (*chreÍa*) of free people. To ensure self-sufficiency it is

7 The term *household sciences* was chosen because it is the most literal translation of the Dutch term *huishoudwetenschappen*. Other English terms such as *Home Economics* do not cover the perspective chosen in this thesis.

necessary to exchange with others, whose excess production corresponds to one's own shortages. Therefore, the art of obtaining is natural and is part of the art of household management (*oikonomikê*)' (translation by DU).

Xenophon, who was a contemporary of Aristotle, also considered that the household depended not only on its labour for self-sufficiency but that household management should also be concerned with increasing wealth through acquisition (*chrêmatistikê*), in order to serve higher purposes (Egner, 1985). However, according to Aristotle there was a risk that the acquisition of goods and wealth could become a goal in itself, and he considered this to be unnatural and at odds with his understanding of household management and his view on people and society. Two thousand years later, the controversy in these opinions—a completely harmonious life or growth in capital for investments—still motivates economic thinking (Egner, 1985).

Although household management and the acquisition of wealth were originally both functions of the household, the science of household management has been largely neglected and not been developed as globally as the science of acquisition of wealth (*Economics*). However, the negative connotation that Aristotle conferred in particular on interest and trade has been dispensed with within the context of current economics. The negative side-effects of expanding industrialisation caused the spotlight to focus on households during the 19th and 20th centuries.

3.2.2 Attention to households in the 19th and 20th centuries

The first steps to a systematic approach regarding households were taken from the 1820s onwards in the U.S.A. and Europe, with the introduction of courses in household management and domestic economy. After the Morill Act in 1862 and the Hatch Act in 1887[8], household management courses were taught at the agricultural and technical Land Grant Colleges in the U.S.A., and research on food and nutrition was undertaken. In the years 1899-1908, conferences were held annually at Lake Placid and problems relating to the influences of the industrial revolution on the home were discussed. These problems included: (1) the increasing division of production, consumption, and upbringing over industry, household, and school, which made household management more complex; (2) how to improve living conditions; (3) how to deal with poverty and scarcity; (4) the knowledge needed with regard to hygiene, food, and fuels; and (5) how education and science could counter several of the problems. Home Economics, the term that covered this field of issues, was described to stand for:

- The ideal home life for today unhampered by traditions of the past;
- The utilisation of all modern scientific resources to improve home life;
- The freedom of the home from the dominance of things and their due subordination to ideals;

[8] The Morill Act: on the foundation of agricultural Land Grant Colleges; the Hatch Act: on the foundation and linking of agricultural research stations with the Land Grant Colleges with federal research funds.

– The simplicity in material surroundings, which will most free the spirit for the more important and permanent interests of the home and of society' (Richards, Proceedings Sixth Lake Placid Conference, 1904 in: Bubolz and Nelson, 2002).

Important for institutionalising was the formation of the American Home Economics Association in 1908 (along with the *Journal of Home Economics*), which took over the activities and function of the Lake Placid Conferences. Early in the 20th century in the U.S.A. and after the 1950s in Europe[9], household sciences were introduced mainly in agricultural colleges and universities. The creation of this type of study at university level in the Netherlands took place within the framework of the Marshall Plan. The plan had been introduced by the U.S.A. after WWII, with the objective of restoring agriculture and an economy in Europe. Household management and household production were recognised as essential for these objectives. The first professor of Household Studies in the Netherlands, C.W. Visser, followed the example of the U.S. colleges and focussed initially on family decision making from a social-functional perspective, paying extra attention to the fulfillment of needs (Groot-Marcus, 2003).

The evolution in household sciences in general since 1900 was described by Goldsmith. During the first era (1900-1930s) there was emphasis on health, sanitation, hygiene, and the importance of household production as a legitimate form of economic production. The second era (1930s, 1940s-early 1950s) had a work-centred emphasis on efficiency, step saving, task simplification, and standardised work units. The third era (1950s-1960s) had a person-centred emphasis on family values, goals, standards, resources, decision making and organisation processes. The fourth era (1970s-1980s) focussed on the development of a systems framework emphasising the interconnections among family, home, and the greater society. Earlier concepts were incorporated in the system perspective (Goldsmith, 2002). In the Netherlands, as well as the social-functional approach of the 1950s and 1960s, attention is given to the economic value of household production in the 1970s-1980s, and in addition a technological approach is taken up from the 1980s onwards.

According to McGregor (1997) three paradigms of humankind are used in household sciences:
– The mechanical, empirical, positivistic paradigm that assumes humans can be moulded by external stimuli. It assumes that informed, rational people will act on information to satisfy their self-interests and to adopt changes. This paradigm is referred to above and was used before the first and during the first and second scientific eras;
– The organismic and developmental paradigm that assumes people are living organisms that do not simply respond to stimuli from their environment but whose intelligence increases as they shape relationships between themselves and their environments and the resource exchanges in a transactional process. This paradigm was applicable during the third era;
– The contextualism includes effects of family choices on humanity and on the environment and vice versa; private choices have an impact on the larger society and on public and corporate decisions, just as those decisions have an impact on the household. This

[9] At first in the Netherlands and Finland (Richarz, 2002), later in West Germany and Great Britain.

paradigm is an ecosystem approach that includes the diversity of family forms, the ability to adapt to change, the power relations within the households and between families and their environments, and the impact of consumption patterns and socialisation of household members on the rest of humanity as well as on the natural environment (McGregor, 1997; Paolucci *et al.*, 1977; Bubolz and Sonntag, 1988).

This fourth era paradigm is still in use and was employed in this research.

After the 1960s, topics became increasingly specialised; in the U.S.A. this was reflected by specialised departments and by name changes, which led to the Scottsdale Meeting in 1993, where the name Home Economics was changed officially to Family and Consumer Sciences (Richards, 2000). In the Netherlands the household sciences section at Wageningen University underwent several name changes after the 1950s. In 2002 it merged with Agricultural Economics to form one curriculum: Management, Economics, and Consumer Studies.

In retrospect, it is clear that the self-sustaining character of households within society, as referred to by Aristotle, Egner, Presvelou, and East, is still hypothetical; theoretically the mutual influence between society and households has not been fully developed and is not explicitly visible in models.

Richards (2000) describes how contextualism, described by McGregor, can be distinguished in a modern and a post-modern paradigm. The modern paradigm takes closed systems, stability, equilibrium, and centred balance as guiding themes, whereas the post-modern paradigm takes open systems, chaos, non-linearity, difference, particularity, and irregularity. In this thesis the household is seen as a half-open system. As well as Hallman, many authors[10] refer to the advantages of the interdisciplinary character of household sciences to understand how households function internally, as well as in a broader society. Although in the Netherlands formal attention to households as such is diminishing, a household perspective can still develop and is suitable to examine problems relating to households in their wider contexts.

3.3 The functional household science approach

This section describes the functional system approach, as the functional level is the first on which household behaviour relating to environmental issues can best be studied (see §3.1). The term *function* refers to 'the natural action or intended purpose of a person or thing in a specific role' or 'a factor dependent upon another or other factors'. The term *functional* refers to 'utilitarian', 'relating to the purpose or context of a behaviour' (Collins, 1995). The household as a system aims at function fulfillment, and the purpose of household activities is to fulfill needs in specific situations.

Gross *et al.* (1980) distinguish a managerial and a psycho-social subsystem of activities in households. Psycho-social activities have an expressive function and involve socialisation,

10 (Tschammer-Osten, 1972; Paolucci *et al.*, 1977; Darling, 1995; Goldsmith, 1996; Pennartz and Niehof, 1999; Richards, 2000).

morality, loyalty, and personal and interpersonal care in order to meet the developmental, emotional, and recreational needs of household members. The psycho-social subsystem is also related to wider social-cultural and structural themes that are studied in household sciences.

The authors pay considerable attention to the managerial subsystem, the activities of which are functional on two levels: (1) those that involve conscious decisions about resources and (2) the actual operationalisation of activities that are directly related to the material well-being of the household. Managerial and non-managerial behaviour differ in the extent to which (1) new decisions are required in a situation, (2) the behaviour is goal-oriented, and (3) resources are used or developed. Managerial behaviour encompasses process activities such as decision making, planning and organising, communicating, using feedback, and setting goals (Gross *et al.*, 1980). Subject to these processes are functional activities such as production and reproduction, acquisition of resources, consumption, maintenance, governance of technical processes, and storage and discarding in the activity categories Food, Housing, and Textiles (Zuidberg, 1981)[11].

The function of household activities in the managerial subsystem is to satisfy the household group's material needs and to provide the material conditions to meet nonmaterial needs (Zuidberg, 1981) in order to achieve well-being. A number of slightly different theoretical input-throughput-output system household models exist that have hypothetical relationships between the core elements (see Spijkers-Zwart, 1973; Gross *et al.*, 1980; Zuidberg, 1981; Deacon and Firebaugh, 1988; Hardon-Baars, 1989; Paolucci, n.d.; Groot-Marcus *et al.*, 2006). Because the core element concepts visualise the functional household system approach, they are discussed as follows:

- The *household group*, the definition of which is hotly debated: Common ground is that it is the smallest social unit that lives more or less permanently in a house, and when it has more than one individual it is a group if they share some collective daily care, facilities, and mutual relationships, as well as identification with that group (based on Zwart, 1994; Casimir, 2001);
- Another core element in the functional household theory concerns the *material and nonmaterial needs*, which are not only physical but to a great extent are the product of society as a whole. The way needs are fulfilled is shaped in societal culture and is institutionalised differently everywhere, just as households are shaped differently in various societies.
- *Standard of living* reflects needs, goals, motives, standards, attitudes, values, and norms, and serves as a guiding principle to achieve well-being in the managerial subsystem. Formed in part by the values and norms in the outside world, the standard of living is not rigid but adapts continuously to fluctuating circumstances (Groot-Marcus *et al.*, 2006);
- The result of household activities is the *level of care*, realised lifestyle, or level of living (Spijkers-Zwart, 1973; Zuidberg, 1981; Linden, 1995);

[11] Note that the overall perspective in this thesis is *functional*. For these activities the term is used as well for two reasons: (1) Zuidberg originally calls these activities functional and distinguishes them from process activities, while (2) Hofstee refers to these activities as opposed to cultural or structural influences in society on the environment.

- *Resources* are the means by which activities are carried out, and Deacon and Firebaugh (1988) distinguish between human and nonhuman. Human resources can be subdivided into affective (feeling, attitudes, interests), cognitive (knowledge, thought processes, skills), temporal (time, timing), physical (health, the use of the body), and social components (relations, networks, memberships of groups, labour capacity). Nonhuman resources are natural, such as land, water, and energy; physical, such as basic services and infrastructure; and financial, such as previously acquired or processed goods, facilities, space, savings, credits, and money (Steidl and Bratton, 1968; Deacon and Firebaugh, 1988);
- *Well-being* is the subjective experience of the *level* of living, when this is compared to the *standard* of living and the difference is interpreted. Well-being achieved through household management activities appears to involve a combination of the terms *welfare* and *happiness* as used by Allardt (1976): namely, the fulfillment of needs *as well as* the subjective feelings and experiences relating to the satisfaction resulting from the standard of living and the managerial household activities. Spijkers-Zwart (1973) calls the difference between standard and level of living the *aspiration level,* a term that reflects tension and a need for action;
- Feedback loops: when the outcome of activities fails to correspond to expectations, people apply a variety of balancing or coping mechanisms, which can embody cognitive, affective, or behavioural aspects (Pennartz and Niehof, 1999). These strategies can apply to the availability, use, or allocation of resources and to the choice of activities and their intensity, or they can encompass a redefinition of the situation or the standard of living, or even a change in the composition of the household.

In the following figure, core elements of the functional household system perspective are placed within the context of environmental issues.

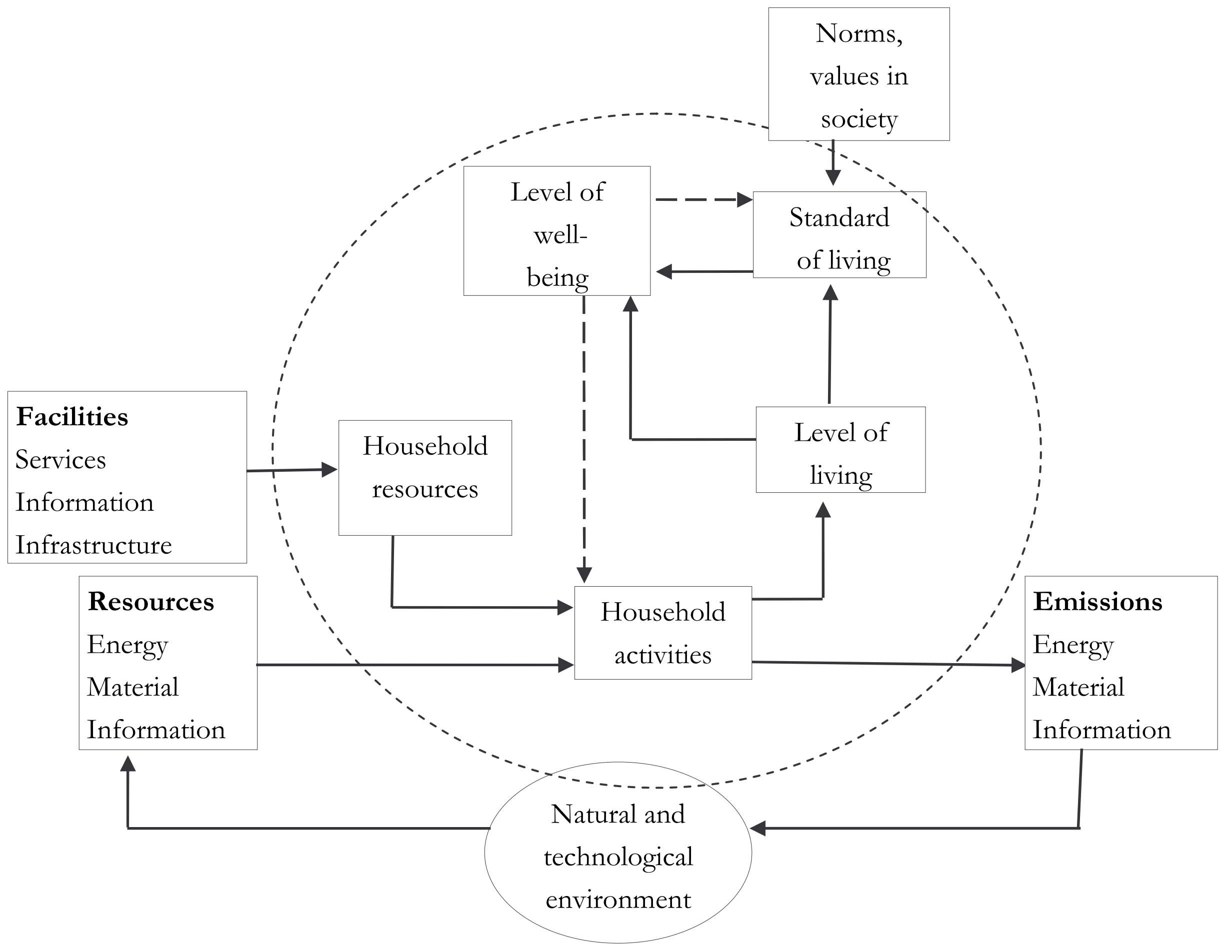


Figure 3.1 *The functional household system in relation to the natural and technological environment (Groot-Marcus et al., 2006)*

Groot-Marcus *et al.* (2006) describe in more detail the interactions with the technological environment and the dynamic reactions within households when technologies are introduced. Because the household is seen as a dynamic system striving for a state of equilibrium, it requires feedback mechanisms to maintain its stability over time. When a new technology is introduced, interactions occur between the new technology and the different core elements of the household. These interactions might upset the balance and cause counter-reactions; hence new technologies that aim at any kind of improvement first need to be investigated in terms of their compatibility with the core elements, the expected responses, and the new equilibrium of households. This will ensure that the goal is reached and with no undesirable side effects. However, adapting skills and striving for development allow irregularity and change (Groot-Marcus *et al.*, 2006), and households benefit if change happens such that core elements change at the same speed. It can also be assumed that changes that do not fit within activity patterns, or that will lead to diminished well-being, are unlikely to be accepted or maintained for a long period.

The household situation is relatively important in terms of which standard of living is adhered to, which resources are used or developed, and which changes can be applied. The influence of a situation encompasses the consequences of preceding behaviour, both externally (situation) and internally (person). Situational aspects that determine which changes can be applied are, for instance, facilitating conditions, availability of resources and opportunities, and structure of available alternatives (Ölander and Thøgersen, 1995; Baanders, 1998). The situation might be seen as a script, where behaviour simply slots in. If water, a resource, is scarce, one's standards of cleanliness, a value, might change. Standards serve as a basis for actions, for evaluating feedback, and for other interactions. The water example demonstrates that standards are affected by available resources and by the situation, and because they are more visible than values, any change in standards is observable first (Gross *et al.*, 1980). Even so, a situation determines to a large extent which resources and skills are developed and used: for instance, developed routines can be viewed as resources for the smooth performance of day-to-day activities (Gross *et al.*, 1980). The judging or misjudging of situations can influence emotions and cognitive processes and therefore can influence the space for change.

Just as household environments alter, so do household work and activities, along with their meaning and priorities (Leskinen, 1990). Gross *et al.* (1980) mention a technological, a natural, an economical, a social-cultural, and a political environment on three levels that interact with households (see Figure 3.2).

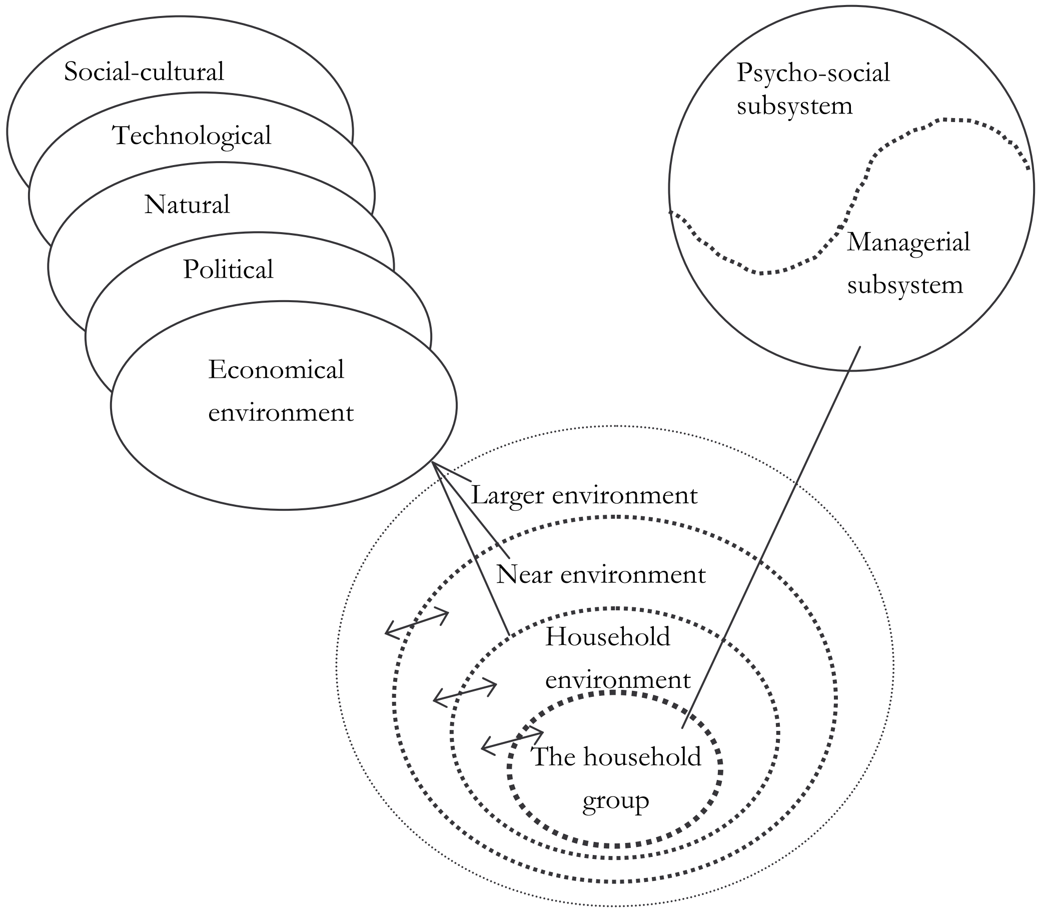


Figure 3.2 The household system and its environments (Gross et al., 1980)[12]

Changes occur at a macro, a meso, and a micro level, in which households can be seen as recipients as well as actors. The first level, the household environment, is the area of activities over which individual household groups have the most control; the near environment is the community in which the group lives, works, or plays; the larger environment is, in general, the society or the culture that surrounds a household group (Gross *et al.*, 1980).

According to Pennartz (2000) and Pennartz and Niehof (1999) the outcome of household behaviour is influenced by internal processes and by external factors, both cultural and structural. The term *internal* refers to what happens in the *black box* of the household. The term *external* refers to the influencing sphere outside the household (e.g. society). The term *cultural* refers to the ideas, beliefs, values, and accumulated knowledge, and to the range of activities shared by a group of people with shared traditions. The term *structural* refers to the organising principles in society (Collins, 1995); see, for example (Pennartz and Niehof, 1999) the following:

- The *internal cultural processes* relate to interaction, ideology, power, and decision making processes within the household (the sociology and psychology of the household group);

[12] Gross *et al.* (1980) use arrows to suggest open, flexible boundaries between the environments; here dotted lines are used.

- *Internal structural factors* concern time schedules, allocation and organisation patterns, and physical conditions: for instance, the insulation condition of the house, or the compatibility of activity patterns between household members;
- *External cultural factors* and views on how household practices and organisation (the internal structure) should be set up and performed. These include the gender frame that is part of a society, or the problems that society thinks are necessary to deal with. External cultural factors influence, for example, the perceived advantages to the household as well as the adoption of innovations and new behaviours such as purchasing PV systems;
- *External structural factors* consist of influential institutions and networks, and they determine household accessibility to provisions; they also influence choices made during the life span of the household.

Certain issues reflect the *structural outcomes of culture*, although these can be different from their related ideology. An example is the task division between partners: The ideology of partners in a household can differ from the demands of external structural influences, and the outcome can be a compromise. For instance, the organisation of childcare is a typical example of how internal and external cultural views on caregiving, as well as external structural provisions, influence the internal structural arrangements employed by households.

Changes in functional activities are influenced by these internal and external cultural and structural factors: for example, the 'production' of a comfortable indoor climate depends on a country's culture and on social class (e.g. the use of flooring material), as well as on the structural provisions to acquire products like heating devices. Responsibility for organising and performing tasks means power, and this can influence the willingness vs. the resistance to change. The course of the family life might also influence the division of household management tasks. For families that have children at an early age, the woman's situation (income, values) has a greater influence on the division of labour. For late-birth families, the man's situation is the main influencing factor (Pennartz and Niehof, 1999). It is also likely that the course of the family life influences the willingness vs. the resistance to change.

In the following section, activities in the managerial subsystem are discussed, and the relation to solutions involving the environment is referred to when applicable.

3.4 Activities in the managerial subsystem

This section describes the kind of knowledge that exists with relation to household activities, starting with an investigation of which activities are carried out in the managerial subsystem. The subsequent focus is on process and functional activities.

3.4.1 Activities

Time budget studies are a source of information on which activities are performed and how much time is spent on them. These studies are often used for a variety of purposes, from sociological or anthropological research on task division to micro-economic research on the

determination of household production values. The use of time is classified into necessary time (sleep, personal needs), contracted time or gainful employment (market labour and education), committed time (household management and housekeeping), and free time (leisure, hobbies, and so on). Managerial household activities encompass contracted (resource acquisition) and committed time (consumption, production, maintenance, and the like).
Household activity[13] classifications differ only slightly throughout the different literature[14] and range from five to seven categories. Of the categories described, mainly consumption, production, and maintenance are visible. Acquisition of resources, which encompasses work and education, is the least visible. Decision making, organising, and planning are not mentioned as such in the time budget studies.

As Leskinen (1990) mentions, using and comparing time budget studies to discuss the significance of an activity is unjustified, as the quantity of time spent says nothing about the satisfaction, the significance, the quantity of input and output, and the quality. According to Leskinen, time budget studies demonstrate no significant change over the years in the total amount of time spent on housework. However, a variation occurs between individuals that depend on their role within the household, the input of internal and external resources, and changes in the relationship of the household with its environment.
Finally, with regard to environmental issues: The environment would benefit if more time were spent on activities that demand less energy.

3.4.2 Resource acquisition

The shift in time input to other internal and external resources is related to how the acquisition of resources is carried out, such as by implementing paid labour, by gaining knowledge or skills, and by investments. That resource management can shift from internal to external has been theorised by Egner and von Schweizer, and investigated by, among others, Drooglever-Fortuijn (discussed later). Like Aristotle, von Schweizer (1975) divides household activities into *hauswirtschafliche Functions- und Arbeitsbereiche* and *marktwirtschaftliche Dispositionsbereiche*. She structures households according to the ratio of these fields of activities on a continuum, with a

[13] The activities consist of preparing meals and setting and clearing the table; doing the dishes; dusting; vacuuming; cleaning windows, doors, floors, kitchens, toilets, bathrooms, and other surfaces; maintaining furniture and floors; airing, beating bedclothing and making beds; doing the laundry and ironing, clearing away the laundry; mending clothes and polishing shoes; tidying up and organising storage space; repairs; designing, laying out, and decorating the interior; daily shopping and major purchases; taking care of the yard, car, and pets; using services such as post offices, shoe repairs, textile repairs, laundrettes, dry cleaners, and so on; using means of transport to shop or use services; preparing for free time and taking care of the indoor climate and warm water (heating, airing). Personal care, care of household members, care of children and others/other households are subdivided into five categories: physical, social-psychological (upbringing/socialising), arranging services, housekeeping tasks, and guidance and transport.

[14] Walker and Woods, 1976; Aldershoff and Baak, 1986; Kirjavainen, 1989; Drooglever-Fortuijn, 1993; Vijgen and Engelsdorp-Gastelaars, 1991; de Hart, 1995; Antonides *et al.*, 1996; Luijkx, 2001.

closed household system (*Geschlossene Hauswirtschaft*) at one end, followed by a self-sustaining (*Selbstversorger*), a service-oriented (*Dienstleistungs*), a contracting-out (*Vergabe*), and finally a cosmopolitan household (*Weltbummler*). In this way Von Schweizer firmly places the household in interaction with society. She states that with society's increasing technological-economical development, the household will become more strongly interwoven with markets, and the *marktwirtschafliche Dispositionen* of the household will become increasingly important. Egner (1985) also writes that the *Hauswirtschaft* can shift to other institutions, which will depend on household preferences, abilities, and resources as well as on developments in its environments. It can be assumed that the management aspects will also become more important because technological-economical developments in society will expand and interaction between households and society will increase.

A shift in energy needs from inside to outside the house occurs when more services and pre-processed products are used. However, at a national and a product level this does not appear to lead to energy reduction in absolute terms (Nonhebel and Moll, 2001; van der Locht, 1998).

3.4.3 Production

Many purchased goods need to be processed to be suitable for consumption. Objects used also need to be brought back to a usable state, clothes for example need to be laundered. This production serves the diverse needs of the household members, but also serves society in terms of regenerated labour power: that is, childcare and upbringing. As mentioned, total time spent on household production has not changed as much as the application of technology might have implied. Circumstances have improved in physical as well as organisational terms, and options to spend time on them have increased. Standards of household production have improved as well, and these developments offset efficiency and time improvements based on technology (Groot-Marcus, 2004; Aldershoff and Baak, 1986). The economic value of household production or the value for insurance companies can be assessed by taking substitutions with equal time and quality (see also Zwart *et al.*, 2002) at market prices, and by calculating the money-income opportunities lost because the individual has spent time on household production. Difficult to assess are (1) the contributions to childcare and upbringing that can lead to socially adapted, productive offspring in the future and avoided costs in terms of criminality and so forth, and (2) costs relating to the effects on an individual's career when she/he has taken time out for childcare (Gross *et al.*, 1980).

3.4.4 The link between resource acquisition and household production

Resource acquisition and household production are embedded in society's current production structure[15], which influences aspects of the relation between this acquisition and production. Aspects discussed here are gender, resource allocation systems, and time constraints.

[15] Industrialisation and modernity: technological innovation together with reorganisation in time and space, which leads to the separation of work and home, individualisation, rationalisation, and urbanisation (Giddens, 1991; Casimir, 2001).

Gender: The gendered division of paid and unpaid work is related to the exchange of time and labour for paid work. Drooglever-Fortuijn (1993) investigates to what extent a household is family or career-oriented (1st dimension) and whether the unpaid/paid labour division is symmetrical or asymmetrical (2nd dimension). The use of these dimensions leads to four ideal types of households, although in reality more multiform and less pronounced types are found. Studies show that when women spend more time on paid work they spend less time on unpaid work. For men, a relation between paid and unpaid work scarcely exists. Women spend on average 2.5 times as much time on unpaid work than men do. The division of housework is more symmetrical when the woman does paid work and when the partners are younger and more highly educated. In addition, less time is spent on cleaning, tidying, and childcare. Higher educated and working women concentrate on unpaid work in the early evening hours and on Saturdays, and use strategies such as increasing efficiency and outsourcing. Pennartz and Niehof (1999) also state that there appears to be a relation between full-time/part-time employment and the type of allocation system of the resources and the social class (i.e. acquisition of resources).

Time constraints: Time budget studies disregard ways of carrying out activities other than ones that are independent and sequential. According to Kilpiö (1980), if time constraint due to labour force participation increases, the person becomes more productive and efficient and does away with created needs. Drooglever-Fortuijn (1993) describes four strategies that can be used to handle household work in time constraint situations, with a major emphasis on a shift in resources: (1) task division within the household, between partners, and between parents and children, (2) outsourcing: exchange or unpaid help from others, paid help, and use of provisions, (3) increasing the productivity by a higher efficiency and use of time saving appliances, and (4) minimising output, canceling tasks, and lowering the standard of living. Several authors (Kilpiö, 1980; Jokelainen, 1969; Walker and Woods, 1976) state that homemakers can carry out home chores more quickly if they improve organisation and planning skills, thus contributing to home production by taking less time. An example is a 30-minute shift in time use from food preparation and cleaning to marketing and management duties. Organisation and planning skills can imply changes in timing: interdependent performance, dovetailing, and overlapping of activities. *Interdependent* activities are those for which one activity must be completed before another can take place (Goldsmith, 1996), thus influencing planning schedules. *Dovetailing* occurs when two or more activities take place at the same time (Goldsmith, 1996). Varjonen (1988) describes dovetailing as simultaneity, which she defines as the simultaneous performance of several activity processes belonging to different activity groups, provided that the processes are carried out by one person. In empirical studies that mainly concern time allocation, simultaneity is described through primary and secondary activities. Varjonen found that at the micro level simultaneity is dominated by childcare and food preparation, depending also on the age of the children. *Overlapping* activities involve a combination of activities that require transferring attention from one task to the other. The emphasis in this thesis is on the combining of tasks, which includes the dovetailing and overlapping of activities, and reflects the preparations that are needed to be able to combine the activities.

Behavioural or technological environmentally friendly changes should match developments in gender patterns, time management, and resource allocation systems in order to support the productivity in households. Just as Leskinen (1990) observed in her comments on time budget studies, no literature was found with regard to variety in the actual performance of tasks.

3.4.5 Consumption

Consumer behaviour and household consumption can be described and investigated in numerous ways, though research has been dominated by the cognitive and emotional aspects of consumption and decision making. Trends in consumption are described in relation to economic, cultural, lifestyle, semiometric (symbols for inner needs, values, and emotions), and demographic factors.

Much less attention has been directed to strategic consumption decisions, or to the process of consumption itself: 'What do we do when we consume?' (Heiskanen and Pantzar, 1997). From a functional household perspective, consumption fulfills the needs of individual members and of the household as a group, and is done to create conditions that facilitate other needs. According to Shove and Warde (1997) a careful examination of current practices and time-management and of the development of the broad, ordinary sense of what is normal is needed. This focus is to analyse the origins of change in and the evolution of normal routines, which are not related to either conspicuous or inconspicuous consumption, and to understand how some forms of consumption become normal in the first place. Possibilities to change the resource intensity of households can then be identified (Wilhite and Shove, w.y; Shove and Warde, 1997).

Household consumption can be indirect (e.g. through communal services and commodities) and strategic, because future requirements and peak loads need to be foreseen. Reinforcement of consumption occurs through specialisation (differentiation in roles, presentations, and activities) and the influence of social-technical systems. The framing of options and possibilities is a result of infrastructure, in the sense of urban planning, the role of utilities, and the organisation of areas like kitchens and bathrooms. In addition, individual consumer goods are embedded and integrated into larger systems (Heiskanen and Pantzar, 1997; Wilhite and Shove, w.y; Shove and Warde, 1997).

Heiskanen and Pantzar (1997) state that in the evolution and stabilisation of institutionalised consumption patterns, social and technological systems interact and integrate with each other. Subsequently, everyday social and psychological processes and micro-social interactions such as routinisation, socialisation, learning, and habit formation allow technological and social systems to evolve towards improved reproductive quality. It becomes progressively difficult to change individual consumption patterns or the system as a whole. Co-evolution of the technologies and conventions of comfort, cleanliness, and convenience is not subject to policy intervention. The inertia of routinised behaviour patterns is not only related to the subjective interpretations of consumers ('what we need') but also to the objective requirements inherent to networks of commodities ('what commodities need') (Heiskanen and Pantzar, 1997; Shove and Warde, 1997).

In view of this, household consumption is layered and difficult to change, because it is embedded in social-cultural, technical, and structural systems. It also reinforces consumption through everyday processes such as socialisation, routinisation, and learning, as well as the use of commodities and services that are a part of networks. Thus, most household consumption can only be modified when environmentally friendly alternatives are (1) logically embedded in specialisation trends, time-management trends, and in social-technical systems, and (2) adapted to the evolution of what is considered normal.

3.4.6 Decision making and organisation

Kirchler *et al.* (2001) describe in detail the literature and a case study on joint household decision making. In addition to joint decision making, spontaneous, autonomous, and habitual decisions are distinguished. The authors state that joint decisions determine the quality of the relationship, and conversely the kind of decision making process is determined by the quality of the relationship, the power relations, and the level of satisfaction within the relationship. Past decisions, interconnectedness of different matters, dynamics of the decision process (tactics, respect, principles for interaction), shifting goals, the urgency for one of the partners, and having an economic vs. a romantic relationship influence the course of decision making. Partners seek to distribute relative benefit, relative influence, and power equally between them. Topic areas in which decisions are made are separated from one another, and an imbalance in benefit or influence in one area must be redressed in exactly the same area (long-term mental bookkeeping). Matters relating to children represent the most frequent topics of discussion, and financial topics—mainly about goals and the distribution of resources—are the most conflict ridden. Kirchler *et al.* (2001) consider it is of little value to develop a model of decision making that is organised along time lines, since incremental steps move from desires to goals, sometimes repeating the steps taken, because goals may change over the course of a decision being made. Discussions on financial topics occasionally occur, often while housework is being done, and when other topics such as work, children, leisure, and the relationship are being discussed as well. Couples certainly do not sit down with the goal of talking and arriving at a conclusion or a solution.

According to Gershuny (1983): 'Household work strategies may be considered to have two components: decisions about (…) the household's overall balance between paid and unpaid work, and decisions about which members are to be responsible for which sort of tasks'. Drooglever-Fortuin (1993) wrote about this as well, and provides two examples of typical households:

– In households where paid work has priority for both partners, domestic work is arranged around the paid work with an extensive network of paid and unpaid help. The partners work efficiently and make many multipurpose trips. For the care of their children they have nannies, child minders, and day care centres, while in the event of an emergency, neighbours, friends, or relatives are on stand-by. Housework is done by a household help and tasks are made easier by means of facilities like laundries and catering. Household tasks not performed by others are divided fairly equally between the partners. They work on different days of the week or during different hours of the day, or leave home late or return early or do part of their paid work at home. In most households both partners work close to their home, and due to their high income they can solve the time-space problems of their organisation;

- In families where the family has priority, either the wife or both partners arrange their paid work around the unpaid work. Outside help is minimised. In particular when the responsibility is divided symmetrically it is difficult to arrange working hours to suit both partners. Sequential scheduling forms the core of their arrangement, and they leave the house in turn and care for the children in rotation (Drooglever-Fortuin, 1993).

Varjonen (1988) describes how activities can be differentiated into mental or mental and physical: Planning the structure of the day or week, being on call, keeping an eye on children, supervising, and talking occur simultaneously, mainly when physical household activities are being carried out. Daily preparation, planning, and organising of tasks as well as long-term activities (having children, decisions on household production strategies, resource allocation, and striving for achievements) require a broad overview as well as considerable flexibility, discussion, and cooperation with other household members.

The examples demonstrate that different needs, wishes, ways of conferring, and external influences, lead to a variety of solutions in the organisation of household production and daily activites.

3.4.7 Perception of household activities

The perception of household activities might influence the space for change. The appreciation of household work has been a subject of research by several authors. Oakley (1974) describes a distinction in the appreciation of the *role of housewife* and of *housework*. Likewise, van der Vinne (1998) describes a distinction in feeling the burden of responsibility and consequently arranging the planning and organisation of housework vs. the burden of executing the tasks. Housework is described as circular, never finished, unsatisfying, easy to perform but difficult to begin (relating to discipline), monotonous, lonely, low status, and time consuming (Oakley, 1974; van der Vinne, 1998). Hallman (1990) distinguishes ten, more neutrally formulated, dimensions of household tasks: difficulty/ease, concrete results, skills, social and economic security/insecurity, freedom/dependency, and responsibility.

Hallman (1990a) states that the significance of housework to the individual is intrinsically related to the person's own situation, the surrounding community, society and the culture as a whole, operational alternatives, previous activities or imagined possible future activities, expectations about the satisfaction of needs, and control or lack of control over personal resources and external conditions.

An important factor to do with enjoyment, satisfaction, and ease of performance is whether the housekeeping task can be performed without time pressure. Women and men who are more satisfied with how the households run, and who enjoy the tasks more, consider that housework makes a pleasant change from their paid jobs: They see it is a form of relaxing activity that does not involve thinking (van der Vinne, 1998). Van der Vinne found that men more often enjoy housework because it is different from paid work, they have more choice as to when to carry out the tasks, and they do not feel responsible. Oakley (1974) found that women who are more satisfied with their households have higher specifications (norms about result, planning, and establishing routines) regarding the tasks. Another factor relevant to liking/disliking housework is that it is experienced as unrewarding because of its circular nature and because the chores are mundane, invisible, and unacknowledged by other family members. Additional factors include easy combining with other tasks, the opportunity to meet standards, and the timing compared with other activities, especially when a normal workday precedes doing the housework. A male respondent calls it *time space* (van der Vinne, 1998).

A distinction was made between liking to have children, caring for them, and raising/bringing them up. Having children was evaluated as positive. Taking care of them was associated especially with small children; for families with older children the tasks related more to upbringing. Care tasks were perceived as lighter, pleasanter, and easier than upbringing tasks. In addition, the planning and organisation of both housework and child-care was experienced as more difficult than actually performing the tasks. For housework the necessary discipline was one aspect of this; further factors were the circular character of the work, the fact that others had to be persuaded or coerced to assist, and that one had to assume responsibility and think of everything simultaneously. When Van der Vinne asked about making shopping lists, arranging babysitters, making appointments for the children and with repairpersons, she found that women performed these tasks significantly more often than men. However, there was no difference between men and women with regard to staying at home with sick children, getting up at night, or taking children somewhere. Men and women often agreed that women take more responsibility for housework, and that men feel more responsible for childcare than they do for housework; however, this was not evident in the participation in childcare tasks.

With regard to environmental issues, changes are probably easier to implement when they are enjoyed, or when they relieve disliked tasks or lead to pleasant ones.

3.5 Determinants of individual behaviour

The family households investigated for this thesis consisted of more than one person: Thus the group processes that take place are influenced by individuals in the group, who differ in several respects. These differences result in diverse individual aspirations to improve the quality of life, both in household management aspects and in the willingness to accept energy reduction options. Because a household consists of groups of individuals, the focus can be on the one person as well as on group characteristics and processes, whereby aspects at the individual level play a role at the group level. Certain of the energy reduction options were at the household level and could be commented on by the household representative. However other options would be judged differently by household members. Therefore, when a range of behaviours and changes is investigated, the environmental friendliness and the willingness to accept the different options simultaneously might be influenced by individual aspects as well as by the existing household management. Hence it also necessary to pay attention to individual factors. Another reason to consider these is that although the environmental burden arises at the functional level, changes in behaviour can only be achieved through people. Hallman (1990 b) argues that the functional household approach is too mechanised a tool to understand human reality, as are the other most commonly applied conceptual frameworks in household analysis (system, management, production, and individual approach). She states that with the progress of hermeneutics and phenomenology as research traditions and of qualitative research methods it is possible that new approaches will be developed and applied in household sciences. To understand irrational and personal components of human activity cooperation with other sciences, such as psychology and social psychology is necessary (Hallman, 1990b).

Individual factors must be considered, because it is not possible to interview every household member and to investigate the group processes that lead to behaviour-altering decisions. For this thesis the person most responsible for the organisation and performance of household tasks was interviewed, and her/his opinion on willingness to accept changes in the household system was investigated. A respondent is both an individual and the person who describes the daily activities (the representative). Respondents can be perceived as household managers who give an individual touch to the housekeeping activities: for instance, functioning as the gatekeeper for changes in the household. Respondents can probably be placed on a continuum ranging from individual to representative, but an exact location on the continuum can be difficult to determine per household or for types of activities and changes. For laundering, it is more likely that a respondent can be seen as the representative, because it concerns only one activity category. However, 31 energy reduction options in six activity categories were examined, and it was unreasonable to expect that the respondents represented every household member. It should be taken into account that in the general survey, the respondent, depending on the activity or proposed energy reduction option, was seen both as an individual and a representative of the household.

Duijker and Vuyk (1969) claim that a theory to explain the behaviour of individuals should use multiple determinants. They distinguish four categories that influence functional household activities: for example, individual aspirations, norms and skills in consumption, production, resources acquisition, and so forth.

- *Motivational determinants*: These come into play when one wants to achieve or to avoid, using associated behaviour (see e.g. Fishbein, 1967; Ajzen and Fishbein, 1980; Ajzen and Madden, 1986; van Raaij and Pieters, 1988; Ronis *et al.*, 1989; Antonides, 1991; Antonides *et al.,* 1996; Staats *et al.*, 1991; Vroon, 1992; Weiner, 1992; Ellis and Baldon, 1994; Midden and Louw, 1994; van Trijp, 1995; van Meegeren, 1997; Vlek *et al.*, 1997; Meijnders, 1998; Piët, 1998).

- *Operative determinants*: What one has learned or experienced determines behaviour to a certain extent and influences habits and skills (see e.g. Scott, 1977; Bentler and Speckart, 1979; Katzev and Johnson, 1983; Ronis *et al.*, 1989; Ross and Nisbett, 1991; Johansson, 1993; Heijs, 1999).
- *Normative determinants*: These represent the behavioural rules for individuals within groups (see e.g. Maslov, 1954; Schwartz, 1977; Johnson, 1978; Ester and van der Meer; 1979; Elgin, 1981; de Young, 1986; Nelissen, *et al.*, 1987; Wilhelm and Keith, 1987; Weiner, 1992; Beckers, 1994; Richins, 1994; van Meegeren, 1997; Couvret and Reuling, 1998; Piët, 1998; Aarts, 1999; Steg, 1999; Gatersleben, 2000; Heijs *et al.*, 2005; Vringer, 2005).
- *Limitative determinants*: These limit the alternatives for behaviour, e.g. physical, emotional, cognitive, and situational factors (see e.g. Adler, 1979; Antonides, 1991; Åberg *et al.*, 1996; Meijnders, 1998; Pennartz, 1999; Kahneman and Tversky, 2000).

Since the 1970s, knowledge about human behaviour has expanded, both relating to the categories mentioned above, as well as, for example, to automatic behaviour, learning possibilities and how learning takes place, social diffusion, and psycho-physical processes (Green and Kreuter, 1991; Rogers, 1995; Kahneman and Tversky, 2000; Cialdini, 2001; Bartholomew *et al.*, 2006). Individual characteristics and needs find their way within the household system through interaction between members and form the outcomes at a household level. However, these processes are seldom investigated and have not been examined in this thesis.
Which individual or household factors play a role in the acceptance of a range of reduction options might differ for groups in the population (see Appendix 3A: Diffusion of innovations theory). Several authors maintain that giving people the opportunity to choose from a range of options might be more successful, as this would lead to a feeling of justification and empowerment (Ölander and Thørgosen, 1995; van Meegeren and van Woerkum, 1994). Antonides *et al.* (1996) find that the costs of energy-saving reduction options are determining factors rather than positive feelings. He finds that restricted change within an activity category is possible, in the level of effort per activity and in the number of activities. The acceptance of reduction options and spreading them over household activity categories might thus be related to the difficulty/ease and pleasantness of the options. The theory of Mental Accounting is described in Appendix 3A, and involves the mental organisation of individuals, which is assumed to influence the acceptance of a range of changes.

The manner in which the functional household perspective was applied is described below.

3.6 Research on households and energy issues

In the foregoing, household models are described with hypothical relations. In this thesis the focus is on the functional level of household activities, because the actual environmental impact arises from functional household activities, such as consumption. The research problem addressed here is of a contextualistic nature: The consumption of direct and indirect energy by households has global climate change effects, and this energy consumption is influenced by the various household environments.

The household can be seen internally and externally as a dynamic half-open system, with fluid boundaries and in dynamic interaction with its environments, and with psychological and sociological interaction between individuals, which influences household activities. The household group, resources, processes, and activities function in interaction with the environments to provide in *daily as well as long-term* material and nonmaterial needs, continued existence, and regeneration (Zuidberg, 1981; Kleynen and Uitdenbogerd, 1993). In a household, a scarcity of resources must be dealt with to achieve a certain level of living (functional activities). *Aspects of household management are investigated in this thesis because they are expected to influence the space for behavioural change.* Once a balance has been established, it is likely to be maintained as well as possible, since changes involve the extra use of resources. Only when concern for the environment and environmental awareness is part of the desired standard of living or part of the socio-technical external infrastructures can it be expected that functional household activities will be adapted. In practice, environmental awareness does not necessarily lead to changes in daily life. Values and norms, knowledge, and environmental awareness often compete with demands exerted by the situation and the household. Knowing how one should behave is not the same as recognising the specific suitability for one's own situation. It cannot be expected that an elaborate decision making process is set in motion when, for example, a harried mother is rushing to or through a supermarket under time pressure. Because the environment is just one of the issues having the household's attention—priority lies in the daily activities—, the opportunities to stimulate environmentally friendly behaviour should appear in the total set of household behaviour determinants and in the household situation. The situational context influences time pressure and the complexity of the organisation of tasks, and consequently the space for behaviour modification. In addition, a household group consists of members who differ widely. The differences between individuals, the dynamic group processes, the household situation as well as the household management, and external cultural and structural influences are determining factors with regard to space for change.

In the case study, the functional household perspective was used, in particular at the implementation level of laundering behaviour. It was assumed that because the questions about reduction options follow those about actual household behaviour, socially desirable answers as well as cognitive dissonance would be avoided. Household theory concepts used were the social interaction within the household group (the influence of household members on laundering) and available resources, standard of living, and implementation of activities. Individual factors investigated were attitude, experience, differences in attitude toward repeated behaviours and larger investments, moments for change in routines, and how certain tasks were learned. Attitudes were measured with short yes/no anwers to questions regarding reduction options, as well as with open questions. In the open answers, different salient beliefs, expectations, and reasons for attitudes of a limitative, normative, motivational, or operational nature were able to emerge. For laundering, it was assumed that the respondent could be seen as the representative of the household, who gave that activity category an individual touch.

In the general survey, possible changes that could occur simultaneously (referred to as clustering) were examined and the subject was addressed exploratively. The Mental Accounting theory was applied in combination with the functional household perspective, with extra attention given to the organisation of household activities. On this occasion budget studies were used to formulate activity categories; for the application of the Mental Accounting theory, respondents were asked what they did simultaneously or in one go. Their preference for reduction options were related to the characteristics of the organisation of household activities. The idea was to find logical clusters of reduction options. On the basis of two variables—the level of environmentally friendly household behaviour and the willingness to accept—respondents were divided into two groups. Variation within the two variables was examined with regard to aspects of household management and to individual determinants. As in the case study, reduction options for repeated behaviours and daily purchases as well as larger investments were investigated, but this time with more structured questions relating to the motivational, normative, situational, and operational aspects. Because of the number (31) and the diverse characters of the reduction options, the respondent could not simply be seen as the household representative; thus the individual was taken into account as well.

The follow-up survey examined whether the option preferences indicated in the general survey had been applied and what the determinants had been.

4. Case Study of Textile Care

4.1 Introduction

In this chapter, a case study is described regarding energy reduction in the activity category Textile Care, which consists of textile use and consumption, laundering, and other maintenance practices. The activities, in particular laundering, are investigated, and the opinions of households about energy reduction options are examined and verified on the basis of the household activities and characteristics.

Laundering involves a range of activities that prepare textiles for reuse. It is assumed that to achieve energy saving in Textile Care, and in laundering in particular, it is necessary to understand laundering, to know its determinants and energy indicators, and the opinions about reduction options. Energy indicators are the quantities that describe the energy requirement of laundering; determinants are the factors that determine the variance in laundering.

Chapter 3 describes how behaviour and acceptance are approached in different research traditions: the household and the social-psychological perspectives.

- The household science perspective focuses on the household and its activities. When a change in behaviour is desirable for environmental reasons, the actual behaviour, practical obstructions, and reasons for change at the household level should be known and should be the starting point for interventions.
- The social-psychological perspective focuses on the individual and her/his reasons for behaviour. Beliefs about the consequences of changed behaviour and social influence as well as about obstructions and the self- and outcome efficacy of an individual should be known and should be the starting point for interventions. Past or present actions are seen as repeated or automatic behaviour and are not included other than in the form of experiences that influence beliefs.

This thesis begins with the household science perspective, supplemented by concepts relating to the social-psychological perspective. This view implies that past and actual practices are included when explaining existing behaviour, when predicting future behaviour, or when behavioural change is investigated. It also implies that the determinants of both behaviour and the willingness to change are investigated. Perhaps concepts exist that influence both the willingness to change and the actual behaviour, or the relation between the two, but which are not consciously known and expressed. Although most people are willing to behave in an environmentally friendly manner, a discrepancy between actual behaviour and more environmentally friendly behaviour often exists. Concepts related to both actual behaviour and to the acceptance of reduction options, or which influence the relationship between the two, might indicate why this deviation exists.

Based on the general research questions mentioned in Chapter 1, the following arose:

(1) *What does laundering consist of, what are the energy indicators and relevant behaviours, and what are the relations between, and the determinants of, the behaviours?*

(2) *Which reduction options for Textile Care are suitable to investigate? Do households accept these options and what is the domestic energy saving potential? What are the determinants of acceptance?*

(3) *Are behaviour and reactions to proposed reduction options (behavioural change) related? Do behaviour and behavioural change share variables?*

(4) *Can extra saving measures and advice be generated from this household perspective?*

To answer these questions and to formulate reduction options, a study of literature on laundering was performed, and a quantitative study was undertaken on the energy requirement of laundering. A pre-survey was held to determine which aspects of textile care were relevant. Finally, a case study was performed using oral interviews and a quantitative questionnaire to investigate what laundering consists of and to examine the acceptance of energy-saving laundering practices.

In the following, first a short report of the literature study (§4.2) and the quantitative study (§4.3 and §4.4) on energy reduction options is given. The research structure, the methods of analyses (§4.5), and the case study sample (§4.6) are described. In section 4.7 the results on laundering are given. In section 4.8 the responses to reduction options and the relations to other variables are described. In §4.9 the variables shared by acceptance and related behaviours are described, as are variables shared by the more widely defined behaviour-option pairs (§4.10). The energy-saving potential is described in §4.11. Finally, answers to the research questions are given, along with conclusions (§4.12).

4.2 Literature on laundering and textile consumption

The current domestic laundering process consists of pre-treatment, washing, drying, ironing, folding, and putting away. The pre-treatment comprises gathering laundry, sorting, turning clothes inside out, checking pockets, closing zips, treating stains, and filling the washing machine in a specific way. The washing consists of machine (loading, temperature, and programme choice) and hand washes. Drying of the laundry includes the place for line drying, re-sorting for tumble drying, and tumble dryer use. Other maintenance practices include airing, hanging out, repairing, and dry cleaning. Textile consumption consists of buying new or second-hand items, using, wearing out, discarding, and reusing or recycling.

Washing and drying

Consumers obtain information about how to wash and launder from the following sources:
- Advised use of laundry appliances as found in use instruction booklets;

- Advised textile care such as from labels on textiles, instructions for appliance use, home economics text books, instructions in the health sector, consumer organisations, private persons (e.g. mothers).

Consumer advice in these sources is summarised in Table 4.1.

Table 4.1 General laundering advice

Advice
– Fill the washing machine loosely with the articles (at the most ± 4.7 kilos)
– Separate colours, in particular dark from light
– Separate materials such as cotton, synthetics, wool and fine, wash with adapted programmes (water level and mechanical action), temperatures and loads
– Wash coloured clothing with a bleach-free detergent
– Wash wool and silk with an alcalic detergent, silk by hand
– Do not wear fine, synthetic, and silk materials too long, as these materials are vulnerable and do not stand up to aggressive washing methods; in particular, synthetics grey irreversibly
– Close zips, turn upper clothing inside out, check pockets to avoid damage
– Cotton and linen can be washed with a full load at temperatures up to 95°C
– Synthetics are advised to be washed in 2.5 kg loads, at 30-60°C
– Wash wool and fine (1 kg) and silk (hand) cold to 30°C

Ample literature on laundering research has been published, much of which focuses on the technological aspects, while other publications focus on the manner of laundering. The information concerns consumption patterns and behaviour in a quantitative way, such as market penetration, weight of the loads, amount of laundry, wash frequency, wash temperatures, and time allocation. These characteristics are related to a limited number of demographic and household characteristics, such as household size. From a humanities or social science perspective, publications about laundering are rare: for example, describing norms and values or social processes related to laundering. Finally, certain publications deal with the results of standardised tests prescribed by the IEC (1994, 1997, 2003) for using washing machines, detergents, and tumble dryers.

From the sources that describe consumption patterns and behaviours, the following is known: Most households in the Netherlands currently possess a washing machine (98 percent); the wash frequency has increased since the 1950s, and the amount of laundry had increased from 4.2 kilos/week per household in 1950 to 16.5 kilos/household.week by 2003 (Hoogland, 1978; Groot-Marcus and van Moll, 1996; Hloch, 2003); the amount of laundry per person has increased even more as the average household size has decreased from 4.2 to 2.4 persons in the same period. In other words the amount of laundry per person has increased by a factor of 6.7 (Uitdenbogerd, 1997). Although not only clothing is involved, there appears to be a shift from changing clothes once a week to nearly every day. Wash temperatures have also changed. In 1980, 20 percent of the washing was done at >85°C; in 1991 it was only 7 percent. The current average wash temperature is ± 47°C in Europe and 49°C in the Netherlands

(Gunnarsen *et al.*, 2003) and the average load is 3.3-3.5 kg/cycle (Terpstra *et al.*, 2003; GEA, 1995). In 1998 the 40ºC cotton programme made up almost 27 percent of all wash cycles and is thereby the single most used wash programme, immediately followed by the 60ºC cotton cycles (25 percent). All 30º and 40ºC cycles together amount to 66 percent of the washes (47 percent cotton, 13 percent easy care, 6 percent wool, and other) (SAVE II, 2001).

The number of households with tumble dryers has also increased. From 1992 to 1996 the penetration rate in the Netherlands rose from 38 (1992) to 50 percent in 1996 (van Maanen, 1994) and to 59 percent in 2004 (CBS, 2006). The tumble dryer is used 3.1 times a week (van Dijk and Siderius, 1991; Aarts, 1995) with 3 to 3.3 kg/cycle. Forty percent of owners dry all their laundry in the tumble dryer, while 60 percent use it to dry only a part or none of their laundry (Aarts, 1995). On average, 62 percent[16] of the owners' laundry (kg) is dried in a tumble dryer. The trend in the penetration rate of dryers is still increasing, although slowing down. The life expectancy of washing machines and tumble dryers is about 10-12 years.

It can be concluded from the above that laundry practices have altered during the past two decades and continue to do so.

From the literature about household characteristics that influence wash frequency, wash temperature, and wash load weight, the following is known: Households with children have more laundry per person than do two-adult households, and households with children not only wash more frequently in general but also have higher loads when washing at 60°C or more (Groot-Marcus and Scherhorn, 1994). In Germany, Hloch and Krüssmann (1991) have also found that households with four or more persons use relatively more hot programmes. The frequency, the amount of laundry and temperature in general thus increase—but not linearly—with household size, although Hloch and Eggeling (1989) have concluded that temperature is independent of household size. On the one hand, the weight of the load decreases with decreasing temperatures and for the different kinds of programmes (95°C, 60° cotton, 60° delicate, 40-30°C cotton) but on the other hand, loading increases with household size (Hloch and Eggeling, 1989, Groot-Marcus and Scherhorn, 1994). The family life cycle and the age of the respondent have no effect on level of loading (Groot-Marcus and van Moll, 1996).

It has been found that for textile characteristics fibre type is related to the weight of the load and the wash temperature, whereas the type and colour of the article are not. Cotton, blends of cotton with synthetics, or synthetics are washed at respectively lower temperatures (Groot-Marcus and van Moll, 1996).

Groot-Marcus and van Moll (1996) have concluded that in terms of household and textile characteristics the explained variation in the amount of laundry and the wash temperature is

[16]Assumption: 40% 16.5 kg; 30% 8.25 kg; 30% 4.1 kg; on average 3.3 kg/cycle (Uitdenbogerd *et al.*, 1998).

low. The variation probably consists of differences in habits as well as in norms or attitudes about sorting and cleanliness.

Dryer use in Britain was investigated by the British Consumers' Association (BCA-RandTC, 1998). They found that although nearly everyone had outside drying facilities, about a third of the tumble dryer owners used the dryer all year round. If the weather was good, the average number of loads dried per week was four; if the weather was bad the average number of loads increased to six. The high heat setting was the most frequently used (79 percent of loads). Half of all loads were interrupted to check dryness, about half of them being interrupted more than once. In six out of ten loads, items were removed before the cycle had finished. Dryers were used often for cotton, polyester cotton (PE/CO), towelling, and synthetics, with the cupboard-dry-, the iron-dry cotton-, and the iron-dry synthetics/PE/CO programme. Most people separated loads into dark colours, light colours, and white and light colours together.

Textile consumption

Textile consumption also contributes to household energy requirement. The discarding of textiles is related to wear and tear and reusing textiles reduces the overall energy consumption. About the factors that influence energy requirement for domestic textile consumption the following is known. In 1938 6.8 kg of textile fibres were used per head in Western Europe, increasing to 10.5 kg in 1964 (Pattis, 1969). The per-head use in Europe at present is 14.6 kg[17] (FAO, 1996). The use of cotton decreased in the period 1938-1964 from 59 to 46 percent; the use of wool from 22 to 14 percent; the use of cellulose fibres increased from 19 to 25 percent; and the use of synthetics increased from 0 to 14 percent. The percentage for synthetics even increased to 60 percent in the late 1960s and decreased again to 30-35 percent in the early 1990s; for cotton it was the opposite. Germany for example showed extreme percentage changes in the use of textile materials, whereas Britain was more constant (FAO, 1962-1996).

In terms of money as well as indirect energy, a household in the Netherlands spends the most on clothing (70-80 percent), followed by upholstery (14-20 percent), bedding, and household linen (7-10 percent)[18]. When comparing one person-, two person-, family-, and one-parent households, it was shown that couples bought the highest number of clothing articles and spent the most money and energy on dry cleaning services (Uitdenbogerd, 1997; CBS-BR 1994, 1996; Vringer and Blok, 1993).

As to the reuse of textiles, Dutch waste in the early 1990s consisted of 2.4 percent textiles. In the Netherlands approximately three quarters of the discarded textiles are collected separately (Textiel, 1992). To a certain extent textile waste is not suitable for reuse due to contamination or because it cannot be separated from other materials. Most collected clothing in the

[17] More recent figures from the FAO are not available.

[18] The comparison between these figures, which are an indication of the stock of household textiles, and the washed number of household articles (35%) in the wash loads (Groot-Marcus and van Moll, 1996), suggests that bedding and household linen articles are washed three times more often than clothing articles; this is an indication of the relative use of clothing vs. household articles.

Netherlands is reused or exported to West, East, and North Africa, to the Middle East, and to the former East Block countries. Three times the amount of separately collected discarded textiles in the Netherlands is imported by Dutch industry. Generally the textiles are cut into rags for use in the industry or for reuse in the production of yarns or stuff material.

As to how clothing is discarded, Vrolijk (1997) has found for the Netherlands that torn, worn out, or permanently stained clothes are used as rags in the household or are thrown away. Clothes passed on to friends or family either no longer fit the original owner, are mispurchases, have been worn too often, or do not combine well with other clothing items. As a second option these articles are donated to charities that collect clothing from door to door. More clothing items are discarded by households that buy or receive more items per year, that feel they have too little cupboard space, that do more physical labour, that have more children, and that include a higher number of income earners and more women. Apparently door-to-door collections four to five times per year give the best results, as people become used to the regular removal of old textiles (Brand, 1989). In the literature and from their own survey in the USA, Koch and Domina (1997) have found similar relations: More textiles are recycled by respondents who are female, older, have a higher income, a higher social economic status, and are fashion innovators. Koch and Domina have also found that eco-*active* persons recycle more textiles, while eco-*thinking* persons recycle fewer. No relation exists between fashion consciousness and environmental awareness. Koch and Vrolijk have found a similar division in the reasons for and the manner of discarding textiles.

For the other side of the market, Stroeker (1995) and Smolders and Scholten (1990) have found that households that buy either second-hand clothing, or have a large number of second-hand consumer durables, are younger and have more children and a lower net income. In addition, Stroeker has found that these households have higher expectations that their income will increase. Apparently 24 percent of the households own second-hand clothes, and 60 percent of these households have less then 5 percent second-hand clothing. The items consist mainly of women's and children's garments (Smolders and Scholten, 1990).

Information about the wearing out of textiles is as follows:

- The amount of mechanical wear in washing machines was studied by Vaeck (1966), and was shown to be about 2.5 percent for 20 launderings, and up to about 4 percent for 30 launderings. The findings on mechanical wear due to washing indicated that wear and tear occurred more during use than during washing;
- According to Krüßman *et al.* (1996), 15 percent of the damage was related to textile care, 20 percent to wearing, and 65 percent to a combination of damage during wear and textile care;
- Textile properties and wear out over time influence the energy consumption for washing as well. Shrinkage and the specification of water uptake during the lifetime of the textile loads are the most important parameters for the amount of water in the main wash and consequently for energy consumption values. According to Sommer (2001), the structure and dimensions of textile articles in the load are less important for energy but are

significant to determine washing performance; he says they should be specified, as well as the type of yarn and how the items are sewn.

Whether households wash and dry new or faded articles differently could affect energy consumption. The purchase of new and second-hand textiles does not reflect actual need: Textile articles might be passed from one household to another; the intensity of use and consequently the stock (the amount of clothing and other textiles) and lifetime could vary; and many inexpensive but poor quality articles or less expensive high quality articles might have been bought. Aside from the aforementioned, scant literature is available on these aspects of textile use and the consequences for energy requirement.

In general, no information can be derived from the literature about household factors that influence domestic laundering/textile consumption.

4.3 Energy requirement for textile care

The energy requirement for textile care involves direct and indirect energy use. Direct energy like electricity and gas is used within the system boundaries of the household as opposed to indirect energy requirements. Direct energy is needed for the use of washing machines, tumble dryers and spinners, and irons and sewing machines. Indirect energy is embodied in the stock of different textile materials, the washing machine, the tumble dryer or other drying facilities, the spinner, detergents, and equipment such as irons, ironing boards, and clotheslines or drying racks. Before an overview of the energy requirement for textile care is given, two aspects are highlighted: the energy requirement for washing and for textiles.

The Dutch figures for washing can be seen in Table 4.2. For comparison, the averaged European figures are given as well.

Table 4.2 Washing characteristics and the energy requirement (e.r.) of wash cycles

	The Netherlands [1]		Europe [2]	
Mean load/cycle (kg)	3.5		3.0	
Frequency per week	4.7		4.6	
Distribution of wash cycles		e.r./cycle		e.r./cycle
30-40°C	57%	4.9 MJ	47%	4.9 MJ
50-60°C	33%	9.8 MJ	37%	10.7 MJ
70-90°C	10%	17.5 MJ	15%	18.5 MJ
Energy use (MJ/kg laundry)	2.2		3.0	
Energy use (MJ/hh.y)	1810		2070	

[1] *GEA, 1995; Van Dijk and Siderius, 1991;* [2] *GEA, 1995*

According to SAVE II, the EC study on the revision of energy labelling and targets for washing machines (2001), the energy consumption for 60ºC cotton cycles decreased from 0.30 kWh/kg in 1993 to 0.24 kWh/kg in 1998, and both absolute and specific water consumption decreased. For the 40ºC cotton cycles this is 0.13 kWh/cycle. There has been no change in average spin speed, which was 877 in 1993 and 858 in 1998.

The diversity in textile articles and the routes to calculate environmental impact are nearly endless because of the diversity in fibres, in agricultural and textile production methods, in finishing techniques, and in cleaning methods. In general it is estimated that the growing of fibres, the finishing techniques, and the use and maintenance of textiles have the highest environmental impact (Slob *et al.*, 1999).

For the indirect energy embodied in textiles, Potting *et al.* (1995) have analysed different materials (see Table 4.3). This energy is needed for production in general and for distribution and waste treatment.

Table 4.3 Indirect energy requirements in the Netherlands for different clothing materials

	Energy intensity (MJ/kg)[1]	Average use (kg/hh.y)[2,3]	Percentage of average (%)	Total[4] (MJ/hh.y)
Cotton	245	10.65	57.2	2609
Wool	215	1.88	10.1	404
Flax	205	0.03	0.2	6
Cellulose	333	0.85	4.6	283
Synthetic	320	5.20	27.9	1664
Average	267	18.61	100	4967

*[1] Potting et al., 1995; [2] FAO, 1992; [3] CBS-BR '90, 1996; [4] Total = Energy intensity * Average use*

Four comments need to be made on the data in Table 4.3:
- These figures are just for clothing. Household textile articles (i.e. household textiles with the exception of clothing) have not yet been taken into account. Household textile articles represent ± 35 percent of the total number of articles washed (Groot-Marcus and van Moll, 1996), which suggests that the indirect energy use for textiles is about 35 percent higher, depending on the weight and the relative frequency of washing different types of articles;
- The energy intensity for the different kinds of fibres is a rough calculation and possibly 25 percent too high. It depends among other things on whether only fossil or also biomass energy in the production stage is taken into account (Potting *et al.*, 1995);
- The FAO figures for clothing are based on import and export figures of national trade statistics. National production is not included and is estimated to be 5 percent of the net figures (Tap, 1997);

- The FAO allocates blends to the predominant fibre, using international standard conversion tables of the weight of the garments.

An overview of indirect and direct energy requirements for textile care is shown in Table 4.4, which depicts energy requirements for clothing, washing, drying, and the contribution of detergents, water, and other equipment. Textiles and washing and drying contribute the most to the total energy requirement. Non-electric requisites and water are relatively unimportant.

Table 4.4 Energy requirements for textile care (MJ/household.year)*

	Direct (MJ/hh.y)	Indirect (MJ/hh.y)	Total (MJ/hh.y)
Textiles	-	4967[4,5]	4967
Use of electric appliances			4506
- Washing machines	1810[1]	100[1,2,3,6]	
- Tumble dryers	2164[1]	100[7]	
- Spinners	41[1]	100[7]	
- Irons	176[1]	14[1,2,3,6]	
Non-electric requisites			100
- Washing and ironing req.	-	34[2,3,6]	
- Brushes/brooms/sponges	-	55[2,3,6]	
- Accessories for cleaning app.	-	11[2,3,6]	
Water	-	102[2,3,6]	102
Detergents	-	1021[2,3,6]	1021
Total (MJ/hh.y)	4191	6505	10696

* *Figures calculated using the following references: 1 Weegink, 1996; 2CBS-BS 1990, 1996; 3Potting et al., 1995; 4FAO, 1994; 5CBS, 1996; 6Biesiot and Moll, 1995; 7 Originally, the expenditures for dryers and spinners in the CBS-BR 1990, 1996 on which indirect energy requirements are based are aggregated in the expenditure category Washing machines.*

The figure for tumble drying takes into account the different energy use and the penetration of air-vented and condenser tumble dryers, the selective use, and the indirect energy for the dryer itself. The assumed indirect energy requirement for tumble dryers is 100 MJ/hh.y. Thus the average energy use for drying in a Dutch household adds up to 2264 MJ/y.

4.4 Energy reduction options

Aspects and sources

Aspects that affect energy requirements for textile care are (see §4.2 and §4.3):

- Consumption of textile materials;
- Washing frequency (amount of laundry, weight of the load, article use);
- Wash temperature;

- Use of the washing machine (placement, use of programmes, special buttons, sorting);
- Energy efficiency of washing machines and tumble dryers;
- Possession of tumble dryers;
- Use of tumble dryers (placement, percentage of washed laundry, average load weight, partly line drying, space heating);
- Use of detergents.

Energy indicators can be formulated from the literature: these are the relevant and commonly used quantities that concisely describe or predict the energy requirements of laundering processes. The derived energy indicators are: (1) wash frequency, (2) load weight, (3) average wash temperature, (4) number of laundry types, (5) dryer possession, (6) loading and use of the dryer, and (7) textile consumption. These energy indicators are used to structure analyses regarding laundering behaviour and to formulate diverse energy reduction options. Ideas about reduction options were found in several studies (SAVE: GEA, 1995; Novem: Bor *et al.*, 1996; ECN: Menkveld and Beeldman, 1997; SAVE II, 2001) and it was decided to select options with the following requirements: They had to be available and applicable in the current situation; they had to be related to direct and indirect energy and to the energy indicators (i.e. for washing, drying, and textile use) and to behavioural changes (purchase behaviour and use patterns); and they had to be related to technical changes (different appliances, materials, or products). The reduction of energy use was calculated in cooperation with the GreenHouse project (see Uitdenbogerd and Vringer, 1999).

Summary of energy-saving potential of reduction options

Reduction options and energy-saving potentials are summarised in Table 4.5. The energy savings of these options are based on averaged situations and practices relating to textile care and space heating. The column Savings Aspect shows the savings for the activity concerned. For example, a higher average wash load saves 16 percent of washing itself, which is mentioned in the left column. The right column shows the savings in percentages for the energy consumption of the activity category Textile Care in total: For example, the option of a higher average wash load saves 3 percent of the energy requirement of all Textile Care activities. Of the reduction options in Table 4.5 indicated by *, the related household practices were investigated in the case study. Of the reduction options indicated by ** both the practices and the responses to the proposed reduction option were investigated. In all, they constitute two options for laundering, two for drying, and two for textile use: the six single reduction options.

Table 4.5 Energy reduction options related to Textile Care [a]

Aspects of textile care and related energy reduction options	Savings Aspect (%)	Savings Textile Care (%)
Washing		
Washing at lower temperatures, from 50° to 40°C**	-19	-3
A higher average wash load, from 3.5 to 5 kilos*	-16	-3
Smaller washing machine, 3 kg instead of 4.7-5 kg**	-16	-3
Using the most efficient washing machine	-12	-2
Using a hot-fill/CV connected machine	-9	-1
Use of E-button*	?	?
Drying		
Line drying	-91	-15
A gas-fired dryer**	-50	-8
Most efficient dryer	-18	-3
A higher average load, from 3.3 kg to 4.5 kg*	-12	-2
Better spin drying, from 1100 rpm to 1600 rpm*	-12	-2
Extra space for line drying (1.2 m^2)**	+7	+1
Use of appliances		
Share the use of appliances by 4 households (W+D)[b]	-2	-0
Lifetime extension (W+D) [b]	-4	-1
Outsourcing (W+D) [b]	+25	+4
Use of materials		
Synthetics under present circumstances (W+D) [b]	-1	-0
Blends of PE/CO (50/50) in bedding ** (W+D) [b]	-10	-2
Three sets woollen clothing: effects on washing**	-1	-0
Three sets woollen clothing: effects on space heating	3[c]	-15

*[a]Uitdenbogerd and Vringer, 1999; see also Appendix 2D; [b](W+D) washing and drying; [c] 3 percent for space heating: 3 percent of 54 GJ/hh.y (1.6 GJ/hh.y)); * Practice investigated; ** Practice and acceptance of energy saving option investigated.*

Relative importance of energy reduction for laundering

With respect to the energy reduction potential of textile care and laundering in the household, the following can be said:

- According to the SAVE II study (2001), no breakthrough in washing machine technology occurred between 1993 and 1998, nor can new insights be foreseen from lab experiments running today. Various technological options have matured and been implemented. The basic electro-mechanical concept has evolved to an electronically controlled machine with sophisticated sensors and sophisticated motors and heating element controls. The percentages of wash, energy, and drying performance in labelling classes A to C increased significantly between 1993 and 1998 at the expense of classes D to G. This increase has been most dramatic for energy performance, followed by wash performance (SAVE II, 2001);

- Compared to the total average energy requirement of Dutch households, which is roughly a quarter of the total use by the Netherlands, the energy use associated with textile care is 4-5 percent. Even if the penetration of tumble dryers rises to 80 percent, the amount necessary for textile care will not exceed 5 percent;
- Assuming that except for line drying and outsourcing, 50 percent of each option is feasible, then for domestic laundering an energy reduction of about 5-6 percent is possible, or 0.55 GJ/hh.y. This is ± 1 percent of the total energy requirement of Dutch households, which is altogether is 3 times less compared with 1°C less room heating; compared with this the number and complexity of reduction options for Textile Care are relatively high.

It can be derived from the above that the remaining and relative energy-reduction potential for textile care is low.

However, the relevance of the case study involving Textile Care lies in the development of scientific insights with a household perspective. As described in Chapter 1, the household setting is suitable to study and to determine the technology-behaviour interactions for both indirect and direct energy, which will influence the reduction potential. In addition, the respondents' acceptance of reduction options is verified on the basis on household characteristics and practices, in accordance with which general guidelines for the acceptance of energy reduction options can be generated. In short, the household perspective is expected to add to existing theories about behavioural change and to supplement general guidelines for the acceptance of energy reduction options by households.

4.5 Pre-survey results and case-study structure

Pre-survey results

The pre-survey was performed to determine which aspects of textile care were the most important and determinant, as well as to find ways to structure the most suitable questions for the case study.

One can imagine that a high wash frequency and high textile throughput are related, but both can also be influenced by household characteristics such as income, and by related practices such as shopping behaviour. Practices can be classified as acquisition, storage, maintenance, use, and discarding (the functional activities of a household). However, only meagre information is available about the relation between use, stock, maintenance, and disposal of textiles in households. Moreover, little is known about how best to structure questions about the daily practices of households.

For the pre-survey, women in 18 households consisting of four types were interviewed: These were one person-, two person-, family, and one-parent households in three age classes: younger than 35 years, between 35-60 years, and older than 60 years. Recruitment was done by telephone in the city of Arnhem.

Relevant aspects of the pre-survey are described below (for more details see Uitdenbogerd *et al.*, 1998).

Characteristics of acquisition, use, maintenance, and discarding of textiles were inquired about in a qualitative and a quantitative way. In addition, the stock of clothing at home was assessed and the number of average wearing and using days and the wash frequency were inquired about. The stock of clothing in a household possibly influences laundering behaviour as well. The following relevant relations were found:

- The stock of clothing per person (28 kg) was about six times more than is normally purchased yearly per person. In increasing order, ranging from 14 to 23 articles each, a person owned dresses and skirts, trousers, T-shirts, jumpers, and blouses. The lifetime of skirts was seen to be more than two times longer than that of trousers;
- Of five approaches to determine a measure for clothing stock, the length of hanging rods appeared to give the highest positive correlation with the number of articles counted. Nevertheless, it was difficult to ask about and to estimate the stock of clothing in a short, quantitative manner;
- Results indicated a significant negative relation between wash frequency and number of days an item was worn. The relation of stock to wash frequency and number of wearing days was not significant;
- Analyses of the relationship (irrespective of the direction) between quantitative and qualitative measures showed that the number of wearing days was significantly and often related to acquisition, manner of textile maintenance, use of clothing, and the reasons for and methods of discarding. The size of the stock was related to the use of clothing (other than wearing days) and to the reasons for and methods of discarding.

Variables taken into account in the case study were:

- For acquisition: 'like to shop and buy unplanned' and the use of second-hand clothing;
- For stock: 'the length of hanging rods' (corrected for income);
- For wearing: 'change clothing regularly' and 'number of wearing days';
- For discarding: 'method of discarding'.

It was found that specified statements could describe qualitative aspects of functional activities but that it was also important to add open questions. These variables and experiences were used in the case-study questionnaire.

Case-study structure

Household practices regarding textile care and the acceptance of energy reduction options were investigated by means of oral interviews using a quantitative questionnaire that included open questions. This combination made it possible to quantify relations as well as to inquire in more detail. The term and subject 'energy' was avoided in the questions as much as possible; instead, the focus was on the daily practices of laundering and proposing the reduction options as discreetly as possible. This was done to avoid answers that were socially desirable and overtly environmentally friendly. The aim was to interview the member of each household who laundered most often.

Each reduction option was preceded by questions about the actual practice. The open questions made a range of answers possible; this was needed because for many reduction options it was not clear whether economic, social, psychological, household-activity-related reasons or a combination of these influenced their acceptance.

One hundred and four households with children were interviewed in the province of Utrecht (central Netherlands) from February to April 1997. In order to be representative for the Netherlands, 11 municipalities were selected on the basis of number of inhabitants. To prevent too much diversity the households were restricted to one type. It was expected that households with children developed strategies to cope with scarcities of time and money, which could influence the acceptance of reduction options, and so this type of household was chosen. Besides, roughly 40 percent of households in the Netherlands consist of this type, comprising ± 59 percent of the Dutch population (CBS, 1996).

On average an interview lasted an hour, and respondents were recruited by telephone, the 'snowball method', and at schools, libraries, and youth sports clubs. At first households with a child younger than the age of one were excluded, as it was expected that babies would influence the laundering practices to a large extent. However, this exclusion hampered the process, so halfway through the recruitment these households were included as well.

The questionnaire covered a number of general aspects. As well as the regular demographic and household characteristics like age, household size, income, and so forth, extra attention was given to work hours, professional status, social economic status, and environmental awareness. It was expected that these had an impact on aspects of laundering, such as sorting and planning, and on preferences for reduction options.

- Available time was distinguished in working hours and extra time spent outside the home, excluding working hours. Households were also asked whether they sometimes experienced unexpected time shortage problems and how they resolved these.
- To determine the professional status of the respondent and her/his partner, the respondents were asked in open form 'what kind of profession' they had. Later this was coded into eight categories: (1) director/manager, (2) owner, (3) farmer, (4) high-level employee, (5) mid-level employee, (6) low-level specialised employee, (7) low-level unspecialised, and (8) housewife. Social economic status (SES) as a variable consisted of education and professional status. SES was coded into five hierarchical categories. Both recodings followed the method of the VMO, the Dutch organisation of market research agencies (1991).
- Environmental awareness was measured by adding five items related to environment friendly behaviour: closing curtains, separating waste, using a water-saving shower head and energy-saving light bulbs, and green electricity. Although Cronbach's α is low (.46),

these items were used to form the scale for environmental awareness because no other measurement was available in the survey.

Aspects in the questionnaire that were expected to influence textile care, and from which the figures for the energy indicators could be derived, are mentioned in broad outlines in Table 4.6.

Table 4.6 Textile care aspects investigated

General aspects	Aspects in detail
Equipment	
Washing machine	Type, placement
Spinner	Possession, use, and rotations per minute
Clotheslines	Most and second most used place to dry laundry
Tumble dryer	Possession, type, placement, use, opinions about use, future ownership
Space heating	Heating of spaces with dryer and clotheslines
Run lines	Influence of number of run lines on the purchase of a dryer
Textiles*	
Wearing of clothes	Use time in days of blouses, T-shirts, etc; number and type of articles worn on the day of the interview
Use of bedding	Use time in days, material, number, and type of articles
Stock of textiles	Length of hanging rods
Use time other articles	Towels, kitchen towels
Purchase and discarding	Three aspects influencing purchase and five ways of discarding of old articles
Laundering	
Arguments to launder	Six arguments to launder, such as smells, spots or stains, after wearing x days
Sorting	Types of laundry, use of washing machine programmes, and special buttons
Loading and reasons	Weight of the load, folding the laundry, reasons for not fully loading
Planning/timing	Planning of laundering during the week and for what reasons
Changes in laundering	By family members, in temperatures, for worn out clothes, in time shortage
Detergent use	Use of several types of detergents, influence on load weight
Restricting measures*	Measures that reduce wash frequency and temperature and wear out
Perceived influence	Perceived of influence of household members on textile care

** Details derived from the results of the pre-survey*

In addition to these aspects, respondents were asked to give a full description of each weekly wash cycle, as well as the less used cycles (e.g. washing sleeping bags once a year).

4.6 Sample description, representativeness, and methods of analysis

The statistics of one-family households in this sample were compared with the national statistics (see Table 4.7). Distribution over municipalities (size), net income per month, house ownership, and the work hours of men were comparable with the national situation for households with children.

The comparison of job ownership was distorted by two factors: Firstly, the national statistics included two-person households with two adults, who would relatively more often have two jobs; secondly, in the sample it was not asked whether benefits were received or whether adult children had an income.
The difference in distribution of the number of children was not unexpected, as households with a baby were excluded at the beginning of the recruitment, which probably influenced the number of households with just one child. The size of the households was on average 4.2 (minimum 2 – maximum 8). The average age of the respondent was 39.8 (minimum 26 - maximum 53) and of the partner 41.2 (minimum 25 - maximum 56). The age of the eldest child varied from 1 to 28 years, mean 11.8 years. The average age of the woman at the birth of the first child (27.6 years) followed the same normal distribution as the national statistics (28.6 years) (Kolmogorov Smirnoff Goodness of Fit test: D= 0.14; p= .029).

Regarding education, it was clear that highly educated people were relatively often present in the sample. The number of women that had a paid job was also higher than average: 64 percent in the sample to 48 percent in the national statistics (c^2= 11, df= 1; p= .001). It was decided not to weigh for this, as it made the results less insightful. Female respondents with a paid job worked on average 20 hours per week; 24 percent spend no extra time on obligations outside the household, while the others spent on average 5.8 hours per week away from the home. Partners worked on average 38.4 hours and in addition spent 7.1 hours outside the house.

Nine of the 104 respondents were men. Two did all the cooking and washing, two did all the washing and sometimes the cooking, three did all the cooking and sometimes the washing, and two had no main responsibility for either of the tasks. Eighty-six percent of the women performed all the tasks. Ten did all the washing and sometimes cooked, one did all the cooking and sometimes the washing, one did all the cooking but never the washing and one sometimes did both; 7 percent of the households were run by a househusband, 90 percent by a housewife, and 3 percent were run with the partners having joint responsibilities. Because figures for the Dutch population were unavailable, no comparison could be made as to whether they were representative.

The methods of analyses used in this chapter are described in Appendix 4A.

Table 4.7 Population distribution in the survey sample and in national statistics (CBS, 1996)

	Sample (%)		National statistics (%)		Significance*
Distribution over municipalities		General		General	.138
Below 20,000 inhabitants		33		29	
20,000-100,000		32		42	
over 100,000		35		29	
Net income per month (Euro)					.616
900.- or lower		4.2		8.3	
900.- - 1600.-		23.2		23.7	
1600.- - 2250.-		31.6		32.0	
2250.- or higher		37.9		35.9	
Number of incomes per family					.002
one		36		23	
two or more		64		77	
Number of children in a family					.001
1		21		37	
2		46		43	
3		25		15	
4 or more		8		5	
Education level of the labour force	Men	Women			.000/.000
Primary school/lower professional e.	24	17		24	
Middle general and professional e.	22	34		46	
Higher general and professional e.	28	32		22	
University	26	17		8	
Paid job (age 24-64)	Men	Women	Women	Men	.001/**
No	0	36	52	24	
Yes	100	64	48	76	
Work hours of women/men					.000/.050
1-20	2	58	30	7	
20 or more	98	42	70	93	
Owner of a house					.959
(Working men with underage children)		General		General	
No		31		31	
Yes		69		69	
Number of rooms					.000
3 or less		7		27	
4		29		58	
5 or more		64		15	
Type of dwelling					-
Semi detached/detached/terraced house		84		70	
Flat/apartment		12		29	
Other		4		1	

* *Significance of c^2 goodness of fit test for frequency distribution ($p < 0.10$).*

** *As none of the men were jobless, c^2 could not be computed.*

4.7 Results for Textile Care

A brief description of the laundering process is given in the following section, as well as a summary of the analyses results and a discussion. An extensive description of the laundering characteristics, such as textile use, weight of the load, wash temperatures, wash frequency, and dryer use, is given in 'Domestic Energy-Saving Potentials for Food and Textiles: An Empirical Study' (Uitdenbogerd *et al.*, 1998). Results for the correlation and regression analyses are mentioned there as well. For the questionnaire (including percentages of given answers) and details of laundering, see Appendix 4B. Variables that are related more than once are mentioned in Table 1 of Appendix 4C.

Demographic variables and textile use influence the amount and composition of laundry

The most relevant behaviour within the laundering process involved the wear and use of textiles and the number of days that they were used. The combination of demographic variables and textile use explained the variation in the amount and composition of laundry.

- Textile use consisted of the number of days articles were used as well as the measures taken to prevent laundry: these included leaving clothes for a period and then wearing them again; airing; wearing undershirts; and the 'importance of arguments to launder'. The arguments to launder were distinguished in spots and stains, smoke and food smells, body odours, filthiness, creased or not neat, and a fixed number of days. Higher average use days were related to a lower amount of laundry, less dryer possession, longer textile life, lower white wash temperatures, less use of stain pre-treaters, specialty detergent and softeners, and to less value being attached to arguments to launder. It was calculated that increasing the average use days by one day in family households would lead to a decrease of 100 wash cycles per household per year.
- A higher social economic status (SES; higher education and professional status) was related to longer article use in days, and to whether the respondent felt the influence of other household members; the arguments to launder were less important and restricting measures were applied more often. This consequently led to a lower amount of laundry. However, the stock of clothing was larger. Indications exists that households with 'housewives' and a lower SES class do more laundry than women with paid jobs.

The differences in use days and the importance of arguments to launder and to apply restricting measures can be seen as differences in the standards of social classes. It is probable that differences in the life of articles and the stock size are a result of the effect of standards as well. However, the relation between SES and textile use can be due to practical reasons: different choice of material, type, quality and variety of textiles, different work-environments, different nature of work, and different physical effort with consequences for the dirtiness of the laundry and the time available to do it. Indications exist that a larger stock of clothing consists of more pieces that need special care, which leads to lower loads and to sorting into more laundry types, more use of special washing-machine buttons, and more use of softeners, though not necessarily to more laundry or to a higher wash frequency. The need for careful handling can be for more delicate pieces in the stock of clothing but can also indicate a higher standard for textile maintenance or for clothing in general.

- Respondents who felt influenced by family members usually had a higher SES. They wore blouses longer, laundered less in combination with other household tasks, and had less often a fixed day for washing but washed more when other family members needed articles; the dry loads of white laundry were smaller and the average wash temperatures were lower. It could be derived from the open answers that more influence was *experienced* when even only one member used clothing in a way that was different from the other household members. Respondents often had the impression that this different use led to more laundry. However, it was clear from the analyses that this did not influence the actual amount of laundry, wash frequency, or average wash load weight when compared with other households.
- The amount of laundry and the related wash frequency were also higher when the household was larger. On average the family households in the survey washed 1273 (minimum 207 - maximum 3193) kilo of laundry in 375 cycles per year (minimum 56 – maximum 1100 cycles). Besides the described influence of average use days, SES (which included whether the respondent had a job) and household size, the regression and correlation analyses showed that extra time away from home, the use of duvet covers, and the 'use of only new clothes and not using or buying second-hand' led to a higher wash frequency.
- Being more religious (no / yes but not practicing / yes) was related to higher average wash temperatures and to the application of restrictive measures.

Amount, composition, and planning influence sorting, wash temperatures, and detergent use

The combination of amount and composition of laundry, and the *planning* of laundering determined which of the five distinct 'sorting methods of the bulk' was used. This influenced the average wash temperature, the wash temperature for coloured laundry, the sets of detergent use, and the number of laundry types (general sorting). The latter influenced average load weight and the average number of hand washes — and consequently the washing frequency.

- Planning: most households laundered regularly, when the basket was full or at the weekends. Households with less 'household' time and those with a higher SES — regardless of the actual available free time besides work hours — laundered at the weekends. Combining laundering with other household tasks was related to fewer extra hours outside the house apart from work hours, to lower education level, and to experiencing less influence from other household members. Washing on a fixed day in the week was related to a lower SES, to a smaller house, and to a lower income. Using the night tariff was related to a higher number of inhabitants.
- On average, the households sorted 5.3 types of loads and in total 17 types were mentioned. The five 'sorting methods for the bulk' were 'white', 'white/coloured', 'white/light/coloured', 'coloured' and 'other'. These labels were based on the composition (kilos * type) of the bulk of the laundry; the types were described by the households in their own words. The five methods of sorting did not affect the average load weight. Households that sorted according to the 'white' method had the most laundry, sufficient to

wash most of it in white cycles and still had enough left to sort into an average of seven other types, which led to a low average wash temperature. Households that sorted by 'coloured' washed almost everything in mixed loads using the machine's coloured-wash programme. On average, they sorted into 3.5 types, but did the most hand washes; wash temperatures were slightly higher but the amount of laundry was the lowest and the wash frequency was average. For the 'white/coloured' and 'white/light/coloured' sorters (72 percent of the sample), the temperatures and amount of laundry differed only slightly and were close to the averages. The 'other sorters' had a great deal of laundry, a high wash frequency, and a low average wash temperature; they sorted into colours and not into article or material type. These households appeared to have a lot of clothing to wash. Households that applied the 'white bulk' method (the most inefficient) used 1.3 times more energy (wash frequency * wash temperatures) than those that applied the 'white/coloured' method (the most efficient). However, the sorting method applied was related to the textile use and to the amount and composition of the laundry.

- The sorting method did not influence the average bulk load weight, but the load weights were influenced on the one hand by the white/coloured cycles, which had a higher load weight, and on the other hand by all the other cycles, which had lower-than-average load weights. The average wash load per household weighed 3.4 kg (per cycle 3.7 kg). The weight of the washed loads was a special variable, as it seemed to be influenced by relatively solitary variables. Load weight was influenced on the one hand by the practice of loading (e.g. folding), by environmental awareness, and by the number of children, all of which led to higher loads. On the other hand, load weight was influenced by careful maintenance or high standards for clothing care (use of specialty and fine detergent; softener and stain pre-treater, by washing faded colours more often, higher wash frequency) and by the number of non-family members living in the house, all of which led to lower loads. The two most important reasons for households not to load fully were 'laundry is not clean' and 'risk of damage to washing machine', but these and other arguments were not related to the actual load weight. At least one-third of the households that had an average load of 3.2 kg per cycle could have loaded half a kilo more, but this might have been dependent on the materials in the stock. The theoretical load (3.7 kg/cycle) is not much higher than what was found in practice in this survey (67 percent of the households have an average load weight of 3.5 kg), which raises doubts relating to the advice to load higher. A higher load for the cycles where it is possible will probably have a minor influence on the washing frequency, especially when compared with the influence of wearing and using days.
- The average wash temperature for all the cycles was 48°C and was related to textile use and planning. The temperatures were high mainly for white and coloured laundry, jeans, work clothing, hot cycles, and bedding and towel wash loads. For the other types, the potential to wash at 30°-40°C was more or less achieved. Higher white wash temperatures were related to lower use time of articles (including less changing for activities, less leaving clothes and wearing again, higher importance of spots/stains), less influence of family members, and less use of T-shirts by the respondent and of blazers by the partner. The use of duvet covers instead of sheets, double under sheets, and a higher number of bedding

articles were related to lower wash temperatures in general. The wash temperature for coloured laundry was more related to planning than to textile use: lower colour wash temperatures were related to washing at the weekends or when the basket was full, whereas washing at the weekends (and the respondent having more work hours) was also related to higher white wash temperatures. Generally, wash temperatures for coloured laundry differed in relation to other variables, compared with average and white wash temperatures. Lower coloured wash temperatures were related to negative opinions about wool; more wool and silk detergents and less soak detergents; higher dryer possession; and selective dryer use in summer.

- Detergent use was related to differences in textile use and sorting. On average 3.3 types of detergents were used. On the one hand, a combination of 'colour' and 'wool and silk' detergent use could be distinguished for less laundry, lower colour wash temperatures, and higher loads. On the other hand, a combination of heavy duty and specialty detergents, stain pre-treaters, a short use time in days, a high wash frequency, and lower loads could be distinguished. A higher total number of detergent types were related to a higher income, and the arguments to launder were more important.

Dryer possession and use and space use

The combination of demographic variables, textile use, and the amount and planning of laundry also influenced dryer possession and use along with space use.

- Households with a dryer (60 percent) had absolutely and relatively more laundry and use their articles, especially jeans (take a long time to dry) a shorter number of days than households without a dryer. Also related was that methods were not applied to avoid laundry. These households had a larger house and a larger number of members, and washed more at the weekends. Compared with households that had considerable laundry but no dryer, those with a great deal of laundry and with a dryer were more negative about wool properties. Their arguments to launder were also less important (textiles were washed after a fixed use period), their SES was higher, they worked more hours, they were less religious or environmentally aware, and they used fewer softeners and stain pre-treaters.
- Dryer possession and use were influenced more by the amount and planning of laundry than by the available and used spaces in the house (no relation to the number of rooms used for laundering). It is likely that the high standards for clothing were applied to the house as well and that the combination of amount and planning of laundry influenced the perception of the available space, run lines, and hindrance by hanging a great deal of laundry in a short time. The dryer then functioned as a buffer and cushioned the lack of available or reserved household time and consequently the space needed for line drying. This was evident in the comments of 66 percent of the dryer owners: The main reasons for purchasing a dryer were 'not enough space to dry the laundry in time for the next load' and 'I don't want laundry everywhere'.
- On average, 75 percent (kilos) of the white laundry was tumble dried, 54 percent of the coloured laundry and 19 percent of the fine laundry – on average, 53 percent of the laundry; and on average, of 75 percent of the wash cycles at least some of the laundry was tumble dried. Most households used the dryer inefficiently: 80 percent used the cupboard-

dry setting and 58 percent did not make use of the night rate, although most households used the dryer less often in summer than in winter (71 percent).

- As well as dryer possession, the dryer filling for white laundry was also higher when households washed at the weekends. Tumble-dried load weights were not only higher then but also when the washing machine had a lower spin rate (double energy inefficient), when the dryer had a timer instead of dry programmes, when the dryer was older, and when the households did not have correct information about the costs of a tumble-dry cycle. Higher loads also meant higher wash temperatures. If the number of run lines were a reason to buy a dryer, the loads were lower. Dryer owners had a wider selection of places (attic, staircase, outside, bedroom, and so on) to hang wet washing than do households without a tumble dryer. However, there was no difference in whether the places were heated. Of households without a tumble dryer, 60 percent heated the space for line drying; of households with a dryer it was 50 percent. Thus, apart from the mentioned influences, dryer possession and use might be related to the layout and use of the house as well.

Reflection on laundering and its determinants

The survey results were in the same order of magnitude compared with figures from other literature sources, where the following was found for 3-5 person households[19]: average amount of laundry: 4.6-5.1 kg per person per week (survey: 5.3 kg/p.w); average wash frequency: 7.5-8 cycles per household per week (survey: 7.2 cycles/hh.w); average weight of the loads: 3-3.3 kg/load (survey: 3.4 kg/load); average wash temperatures: 49°C (survey: 48°C).

One could argue that a sorting method consists of several strategies: for instance, one or more for the bulk of the laundry and other methods for the remaining laundry items. It can be derived from the findings that the sorting strategy depends on the amount of laundry as well as on the relative proportion of kinds of textile articles. Consequently the wash load compositions will differ. It is likely that some sorting methods are used more often, or in specific combinations by certain households.

The following can be said about the influence of salient ideas or concepts:

- No indications were found for overall concepts such as planning or hygiene. Probably 'appearance' or impression through clothing, in relation to different detergent use (in particular the specialties, such as softeners, wool/silk, stain pre-treaters, soak, specialty/fine detergents), might be a better concept to explain the wash frequency and other aspects of laundering and careful maintenance.
- Ideas about loading, appliances, and appliance use had more influence on the load weight of tumble dryers than on load weights of washing machines.
- In three other practices it was demonstrated that people's ideas about laundering did not match their actual behaviour or the situation. The felt influence of family members did not lead to more or to less laundry; the experienced shortage of space was not related to the

[19] See Uitdenbogerd and Vringer, 1999, based on Scherhorn *et al.*, 1991, 1992; Groot-Marcus and Scherhorn, 1994; Groot-Marcus and van Moll, 1996.

actual space (more laundry was related to less space use for laundering) but to the amount of laundry and to planning of laundering. In addition, wash load weights appeared not to be related to reasons for the manner of loading.

The above demonstrates that conscious ideas about specific behaviour were not necessarily related to the actual and measured variance in this behaviour. However, concepts such as environmental awareness did influence some activities. Heightened environmental awareness was related to longer use time in days, less importance of arguments to launder, higher wash load weights, more use of energy-saving machine buttons, and lower dryer possession, but was not necessarily related to the amount of laundry, wash frequency, or dryer use.

4.8 Acceptance of reduction options and relations to other variables

The link between behaviour and the acceptance of reduction options is investigated in the following section.

The survey addressed the acceptance of reduction options in different ways. For this survey and within the sample, *acceptance* is understood as the degree to which household members responded positively to the proposed reduction options. Throughout the survey, six single reduction options were proposed: (1) washing coloured laundry cold, (2) a smaller washing machine, (3) extra space for line drying, (4) a gas-fired dryer, (5) more woollen clothing, and (6) blends or synthetic bedding. At the end of the survey a more general and open question relating to five areas was asked: (1) different laundering, (2) different drying, (3) use of other textile materials, (4) longer textile use, and (5) other. All answers were noted both quantitatively and qualitatively.

In the following, firstly the reactions to the proposed reduction options are described (§4.8.1); secondly, the linear and non-linear relations of the responses to the reduction options with the related practices are analysed (e.g. washing at lower temperatures, wash temperatures) (§4.8.2); thirdly, the relationship between the reduction options is analysed (§4.8.3); and fourthly, the relation of the responses to the reduction options with other variables is analysed using a factor analysis (§4.8.4).

4.8.1 Single reduction options and the general question

Responses to the six single reduction options

In the following, responses to the six single reduction options are described. For illustration and when appropriate, the question as used in the survey is added.

1. Reduction option: Washing coloured laundry at 25°C

The option *washing coloured laundry at 25°C* saves electricity and is not uncommon in other countries. It was asked in an open question that included this information:

'*In several countries laundry is washed at 25°C or even in cold water (10-15°C), for example in Japan and Spain. What do you think about the idea of washing your coloured laundry at 25°C?'*

More than half—55 percent—of the households were not willing to change; 25 percent were prepared to change if conditions were met; 17 percent thought the idea was worth trying; and 3 percent thought it was a good idea. Conditions mentioned by the respondents were 'better detergents', 'first published test results in a consumer organisation magazine', and 'washing machines would have to run for a longer period'. In the open answers, 45 respondents considered that it would not be possible to achieve a fresh and hygienic laundering result. In particular, stains, smells, and hygiene regarding specific articles (creases, deodorant stains, sweat, collars, jeans, socks, nappies, underwear, blouses) were given 12 times as reasons not to wash coloured laundry at lower temperatures.

2. Reduction option: Smaller washing machine
In general, a smaller washing machine can compensate for low-average load weights. The question about smaller washing machines included information and was part of a range of questions about loading:

'Most washing machines are made for 4.5 to 5 kilos of laundry. This means that the washing machine is completely filled with folded laundry and that after it is pressed down nothing can be added. However, the average load for a washing machine in the Netherlands is 3-3.5 kilos. Would a washing machine suitable for 3.5 kilos fit your household and laundry practices? Would you load a smaller washing machine in the same way?'

Most of the households (94 percent) disliked the idea of smaller washing machines; 2 percent acknowledged the possibility; 3 percent were positive; and 1 percent was not sure. Two reasons mentioned most often were 'too much laundry – large family' (42 times) and 'washing more often is not attractive' (28 times). Planning, large articles (blankets, sleeping bags, duvets, and double sized sheets) and that a smaller machine would have even smaller loads were each mentioned five times.

3. Reduction option: More use of wool products
The use of woollen materials, jumpers in particular, can lead to having lower room temperatures, but can also influence the average wash temperature and frequency.

'In general, wool needs washing less often compared with other materials, such as cotton. Would you think it acceptable if more articles of clothing consisted of wool or of a wool blend? Why or why not?'

Most of the households responded negatively to the question about whether more woollen clothing would be acceptable.

Table 4.8 Responses to 'more use of wool' (percent, n=104)

Answers	(%)
No	43
Wool is acceptable but I will not have more (no)	22
Yes, more is acceptable (already have a lot of wool)	30
No opinion	5

Reasons mentioned for accepting or not accepting more wool are summarised in 14 categories in Table 4.9, of which eight are negative and six are positive.

Table 4.9 Reasons for accepting or not accepting more wool (more answers possible) (percent, n=104)

Negative aspects	(%)	Positive aspects	(%)
Itches or allergic reactions	28	Is pleasant to wear	11
Means a lot of work	16	Is acceptable if machine washable and doesn't itch	8
Is too warm	13	Wool blends are acceptable	8
It gets dirty as quickly	12	Needs less washing	6
Is risky to maintain	11	Quality of wool is good	3
Cotton stays nicer than wool	11	Just more airing, easy to maintain	2
Is more expensive	4		
Is difficult to dry	2		

4. Reduction option: Blends for bedding

Cotton-synthetic blends absorb less water and therefore dry more quickly and use less energy to tumble dry. The open question regarding whether a blend of cotton and polyester in sheets was acceptable included the following information:

'Synthetic material or blends of synthetic with cotton dry more quickly and are easier to iron. Men's shirts are often made of cotton/polyester blends (CO/PE). Have you ever considered buying sheets, duvet covers, and other bedding with not only cotton but also polyester in them: for example, a blend of 50/50?'

Table 4.10 Are blends of cotton/polyester acceptable for bedding? (n=104)

Answers	(%)
Never thought of it, no intention to buy	77
I have thought of it, but will not buy them	12
I have some but they are not acceptable	8
I have them and they are acceptable	2
Never thought of it but likely to be acceptable	2

Only 4 percent thought that blends were acceptable, which was 2 percent more than the percentage of respondents who already had blend-material bedding. Reasons given were: 'It is easy and doesn't crease as much as cotton', 'although 50/50 feels stiff, a blend of 80/20 cotton/polyester is probably acceptable', and 'has a longer life'. The other 96 percent of the households considered that CO/PE bedding cause sweatiness and stuffiness (25 percent), cotton feels more comfortable (21 percent), they had never thought about it or had no opinion (17 percent), 12 percent thought that synthetic sheets cause itching and allergic reactions, and 12 percent were not concerned about the materials, only about colour, pattern, or price. The other 9 percent said that hard pilling forms, that cotton/polyester blends feels stiff, and that they do not iron sheets anyway.

5. Reduction option: Space for line drying

Space for line drying can replace the need for a tumble dryer or at least diminish its use. When asked whether a special laundry room was desirable, 51 percent of the respondents answered 'yes', 30 percent already had such a room, and 19 percent thought it was not necessary. Of this last group, 12 households had no tumble dryer. Six households that had a tumble dryer would not need it if a specific drying room were available (10 percent of the tumble dryer owners). However, six households that did not possess a tumble dryer would like to have one if a specific room were available. Thus, the presence of an additional room or extra space would not make a difference to the penetration rate of tumble dryers. The presence of lines in the room was desirable for 88 percent of the households. The preferable location for this room was adjacent to a bathroom (27 percent) or to the kitchen (23 percent). The average desired size of the room or extra space was 11 m^2.

6. Reduction option: Gas-fired dryer

The question about the gas-fired dryer included the following information:

'A gas-fired dryer is more expensive than an electric dryer, but it uses half the energy and finishes a programme twice as quickly. A gas pipeline would possibly need to be installed. The payback time of the extra investment is around 3-6 years. After that the gas-fired dryer will be cheaper to use than an electrical dryer. Would you be interested in such a dryer? If so, why or why not?'

Twenty percent of the respondents knew about gas-fired dryers; 65 percent were not interested and 35 percent mentioned a condition, such as 'more information needed' (n=5) and 'cost effectiveness' (would the dryer be used often enough?) (n=26). Positive comments concerned the shorter drying time (n=10) and the importance of energy saving and consequently the possibility to save money (n=17). Other households either wanted no dryer at all or had purchased a dryer recently (n=44). Of the 22 households that expressed an interest under certain conditions and that also commented positively about a gas-fired dryer, only three had a tumble dryer that was 9 years old or older and would probably need to be replaced soon. Four households did not have a tumble dryer. These results indicate a general 3-4 percent increase in the penetration rate of tumble dryers.

Responses to the general question

This section begins with the general change question that is asked at the end of the survey. The answers are later used as additional information to determine causality in relations between responses to reduction options and actual behaviour, and as additional information to calculate the energy-reduction potential of the six single reduction options. The question was divided into five sub-questions:

Imagine a campaign for the care of the environment. What would you change in your household and how would or could you do it? Would there be a change in:
1. Washing? 2. Selective dryer use? 3. Textile materials? 4. Using clothing and household textiles longer? 5. Would there be a change otherwise in textile care?

Responses to the general questions are summarised in Table 4.11. The specific solutions and examples are listed in Uitdenbogerd *et al.* (1998) (Appendix F; Tables 1 to 5). These general questions are marked with 'G:'.

Table 4.11 Responses to the general questions about changes in laundering

Would you be prepared to:	Yes (%)	Households that mention a solution or example (%)
1. G: Wash differently?	51	40
2. G: Use the tumble dryer selectively?	25*	22*
3. G: Use other textile materials?	18	8
4. G: Use articles longer?	32	21
5. G: Make other changes?	-	17

** 40 percent of the respondents have no tumble dryer*

The question about washing was answered positively most often. Approximately 18 percent of the comments were about temperatures, 12 percent about wash frequency, and 8 percent about washing machine use.

Using or wearing articles longer was the second most popular reduction option. Comments included: 'you would have to get used to it but it is possible', or 'air more often', and 'educate children'.

For drying, the third most popular option, about 15 percent of the households mentioned line drying, 5 percent selective dryer use, and 2 percent dryer possession.

Changing to other materials was not a popular choice. Some households thought of futuristic options, such as bacteria-resistant underwear, synthetic materials that do not smell (due to sweat) and with finishes that make it easy to remove stains, and materials that do not crease easily. Only 2 percent of the households were willing to use more synthetics and 6 percent to use more wool.

Seventeen percent of the households mentioned changes other than the six proposed single reduction options. Some households mentioned more than one, such as 'use the ½ button, shorter programmes, and dry for shorter times'. Less ironing was mentioned as well, which is remarkable because this is not a significant source of energy reduction and had not been previously mentioned in the survey. Apparently the impression exists, probably through the heat that is felt during the activity, that ironing consumes a lot of energy.

4.8.2 Acceptance of reduction options and actual behaviour

In the previous section, the acceptance of the five general and six single reduction options is described. In this section the relation between the acceptance of reduction options and the actual behaviour is investigated using Kendal's τ_c. Eight reduction options and their relations are shown in Table 4.12, including future dryer ownership. For three reduction options the analyses could not be done due to the broad scope of the questions and consequently the wide range of answers (G: wash differently; G: other textile materials; G: other changes). The acceptance of the single and general reduction options was aggregated to one variable 'Acceptance'. The relations to this variable are shown in Table 4.13.

Linear relations between reduction options and related behaviour

Six relations between three reduction options and actual behaviour appeared to be significant and linear (Table 4.12; third column from the left).

- When a dryer was owned, respondents were more often interested in a gas-fired dryer and in having a dryer in the future.
- When more space per person and more rooms were available, and the number of run lines were not a reason to buy a dryer, respondents felt less need for extra laundering space.
- When CO/PE sheets were used, the response to the option 'more blends' was more often positive, although not many people used CO/PE sheets.

It is possible that the relation between behaviour and acceptance of the reduction option was influenced by the level of environmental awareness, which was assessed by partial correlation analysis. Environmental awareness was measured by behaviours generally accepted as reflecting it (see §4.5).

For partial correlation, SPSS uses Pearson's R, which can be used for interval variables. This means that Pearson's R cannot be used for the many ordinal variables in Table 4.12. It was checked whether the significant values in the fourth and fifth column were significant for the appropriate level as well. This appeared to be correct, except for 'no. storeys laundry – wish extra laundering space'. Ideally, Kendal's τ_c should be significant as well.

When environmental awareness was kept constant, no relations appeared between behaviours and the related reduction options. Two significant relations disappeared, meaning that, without keeping it constant, environmental awareness had a strengthening effect on the original linear relation. Compare the fourth and fifth column in Table 4.12.

- Respondents that used articles longer agreed to do so more often. This relation was stronger when environmental awareness was higher.
- When the laundering process took place over more than one storey in a house, the respondents felt less need to have extra laundering space. This relation was stronger when environmental awareness was higher.

In general, environmental awareness had no influence.

Non-linear relations between reduction options and related behaviours

Non-linear relations between the reduction options and the related behaviours were investigated with χ^2 (6th column in Table 4.12). To be able to use χ^2, ratio variables were recoded to trichotomous variables, of which each value contained 33 percent of the respondents. It appears that of the 24 relations in Table 4.12, eight were significant, of which six were linear. The two others were parabolic, whereby the group with the average value for behaviour responded differently to the reduction option compared with the groups that had a low or a high value.

Table 4.12 Relations between actual behaviour and the responses to reduction options

Actual behaviour or situation	Reduction option	τ_c (3	P'R(2	P'R (2 Environmental awareness (e.a) constant	χ^2 (1	n
Average wash frequency (r)(4	G: use articles longer (d)	Ns	ns	ns	ns	104
Wearing behaviour (r, t) (4	"	ns	+*	ns (e.a has influence)	* parabolic 2-3 (5	104
Dryer filling white loads (o)	G: use dryer more selectively (t, d) (4	ns	ns	ns	ns	62
Dryer filling coloured loads (o)	"	ns	ns	ns	ns	62
Dryer filling synthetic/fine loads (o)	"	ns	ns	ns	ns	62
Average wash temperature (r) (4	Wash coloured laundry cold (o)	ns	ns	ns	ns	104
Temperature of coloured laundry (r) (4	"	ns	ns	ns	ns	104
Temperature of white laundry (r) (4	"	ns	ns	ns	ns	104
Dryer possession (d)	Interest in gas-fired dryer (t)	.302 (p= .001) **	+**	+**	**linear	104
Space per person (r) (4	Wish for extra laundering space (t)	-.203 (p= .024) *	-*	-*	*linear	104
Number of rooms in the house (r)	"	-.208 (p= .016) *	ns	ns	ns	104
Dryer possession (d)	"	ns	ns	ns	ns	104
Number of rooms used for laundering (r, t) (4	"	ns	ns	ns	* parabolic 2-1,3 (5	104
Number of storeys used for laundering (t)	"	ns	-*	ns (e.a has influence)	* linear 1-3 (5	104
Total kilos laundry/wash frequency (r) (4	"	ns/ ns	ns / ns	ns / ns	ns / ns	104
Number of run lines reason to buy a dryer? (t) (4	"	.180 (p= .025) *	-*	-*	* linear	104
Dryer possession (d)	Wish for dryer in the future*** (o)	.963 (p= .000) **	+**	+**	** linear	104

Wearing days of woollen jumpers (r) (4	Use more woollen clothing (o, d) (4	ns	ns	ns	ns	104
Life of woollen jumpers (r) (4	"	ns	ns	ns	ns	104
Use of wool/silk detergent (d)	"	ns	+*	+*	ns	104
Use of cotton sheets (o) (4	Use more blends for bedding (o)	ns	ns	ns	ns	104
Use of iron-free sheets (o) (4	"	ns	ns	ns	ns	104
Use of cotton/polyester sheets (o) (4	"	.128 (p= .027) *	+ **	+ **	** linear	104
Average load weight (r) (4	Smaller washing machine (t)	Ns	ns	ns	ns	104

(1 χ^2 for nominal levels; (2 P'R = Pearson's R for interval levels, - negatively related, + positively related; (3 τ_c for ordinal levels, significant when p <.05;
*(4 recoded ratio variables, in n=33 percent groups of 1: low, 2: medium, 3: high values, to use chi^2; ns= not significant, d= dichotomous, t=trichotomous, o=ordinal, r= ratio; (5 e.g. '2-1,3' means: group 2 differs significantly from group 1 and 3, i.e. a parabolic relation; * significant for p <.05; ** significant for p <.01; ***potential option*

These two relations were further investigated in detail using Tukey.

- Respondents with an average use time of articles responded more often negatively to the reduction option, especially in comparison with respondents with a high use time (Tukey HSD, p= .009).

The group of respondents that used two rooms for laundering responded more positively to the option ‘more laundering space’ than the groups that used one or three or more rooms.

Linear and non-linear relations with Acceptance

The five general sub questions and six single reduction options were added with equal weight to compute a new variable: Acceptance. The answer categories of the six single reduction options were recoded to ‘0 no’, ‘1 maybe/when a condition is met/I can try’, and ‘2 yes’. The five general questions were dichotomous and recoded to ‘0 no’ and ‘2 yes’. The theoretical maximum was 22.

- The variable Acceptance was normally distributed (KS 1.125; p.159) with mean 6.25 and sd 3.07. The minimum value was 0 and the maximum value was 14 for n=102.
- A reliability analysis of the 11 reduction options resulted in Cronbach’s α= .36. The 11 reduction options could therefore not be used in a scale that measured the general degree of acceptance. The respondents chose diversely and some accepted more options than others, and for this the new variable, Acceptance, was used.
- A factor analysis over these 11 reduction options resulted in five factors (PCA, Varimax, missing values substituted with means, 9 iterations, R^2=.60, KMO: .507, and Significance of Bartlett’s Test of Sphericity: .046). According to Norusis (1990) this KMO value was ‘miserable’. No clusters of reduction options could be distinguished using this analysis.

Thus far these results indicate that the summarised answers regarding respondents’ options were distributed normally, but answers relating to the separate reduction options were different.

For Acceptance, the same analyses were done as for the variables in Table 4.12. Acceptance was being related to four types of behaviour that were expected to reflect flexibility in laundering. The four behaviours are:

- Change in laundering practices when time pressure was experienced or when respondent was not able to do the laundry (Appendix 4B: A048);
- Combining laundering with other domestic tasks (Appendix 4B: t033);
- Wash temperature changed in the past (Appendix 4B: t038);
- Perceived influence of other household members on laundering (see section 4.8 and Appendix 4B: t071).

A reliability analysis of these four variables showed that they could be used as a scale for flexibility (Cronbach’s α=-.01). The variables were used separately.

Table 4.13 Relations between flexible practices and Acceptance

Flexible practices	Relation to Acceptance			
	τ_c [1]	P'R [2]	P'R [2 milieu constant]	χ^2 [3]
Change practices with time shortage (d, o)	ns	ns	ns	ns
Combine household tasks while laundering (t)	-.359 (p= .000)**	**	- **	** 1,2-3
Wash temperature in the past (o)	ns	ns	ns	ns
Perceived influence of family members (d)	.261 (p= .020) *	ns	ns	ns

*[1] τc for ordinal levels; [2] P'R = Pearson's R for interval levels; - / + negative / positive relation; [3] χ2 for nominal levels; d=dichotomous, t=trichotomous, o=ordinal; * significant for p<.05; **significant for p<.01*

- Two of the four variables had significant relations to Acceptance, although the perceived influence of family members gave mixed results for χ^2 (not significant) and Kendal's τ_c (significant). More perceived influence from family members related to a higher score on Acceptance.
- Environmental awareness (fourth column) had no influence on the relations.
- Combining laundering with other household tasks was negatively related to Acceptance. Group 1 (never combines) in particular and group 2 (sometimes combines) scored higher than group 3 (often/always combine) for Acceptance (Tukey HSD, p_{1-2}=.994, p_{1-3}=.001, p_{2-3}=. 046).

The negative relation between combining household tasks and Acceptance was probably caused by differences in carrying out household tasks. More combining tasks was related to a lower education (τ_c -.218, p.007), less perceived influence from family members (τ_c -.282, p.003), less hours extra outside the house (τ_c -.248, p.001) and the dryer was newer (τ_c -.268, p.013). When these variables were kept constant (partial correlation analyses) no change in the relation between combining household tasks and Acceptance occurred. However, there was no relation to number of work hours, having a paid job, net income level, professional class, amount of laundry, or household size. In other words, the relation between combining and acceptance was not influenced by actual time or differences in the amount of laundry. The relation of Acceptance to other variables indicates that more flexibility on one level (more combining household tasks) also yields less flexibility (fewer acceptances, less influence by family members, reserving household time) on another.

4.8.3 Reduction options related to each other and to other variables

Analyses were done to see how the acceptance levels of the reduction options relate to each other and to find the most determining variables. Firstly, the relations between the five general sub-questions and the six single reduction options were investigated. These results are presented in Figure 4.1. Secondly, variables were searched for that were significantly and most highly correlated to the variables about the six single reduction options and the five general reduction options.

Relations between the six single and five general reduction options

Relations between the six single and five general reduction options were investigated using correlation analyses and with Kendal's τ_c. In Figure 4.1 the significant relations between the acceptance of the six single reduction options and five general reduction options (G:) are shown. Positive relations meant that when one reduction was accepted, the other was as well. Negative relations meant that one reduction option was accepted but the other was not.
It could be expected that when the *single option* was responded to positively, so was the *general question* on the same topic. Conversely, answering a general question positively did not mean that a more specific single option was answered positively as well.

- Of the six single reduction options, three (washing cold, wool, gas-fired dryer) were significantly related to the general questions about changing behaviour.
- There were three positive relations between the general questions. G: selective dryer use, G: use articles longer, and G: other changes were positively related to G: washing differently.
- No relations existed between the single reduction options. This was an indication that the single options were responded to with distinctions.
- 'Smaller washing machine', 'extra space for laundering', 'G: other textile use', and 'blends for bedding' were not significantly related to any other option; for the first and the last due to prevailing negative answers.

Households with a dryer were more positive towards a gas-fired dryer (τ_c = .30; p.001, n=104) compared with households without a dryer. Households with a dryer were negative about the properties of wool and consequently did not respond positively to the option 'more wool' (τ_c =-.26; p.02, n=104). Responses to the other options differed only slightly.

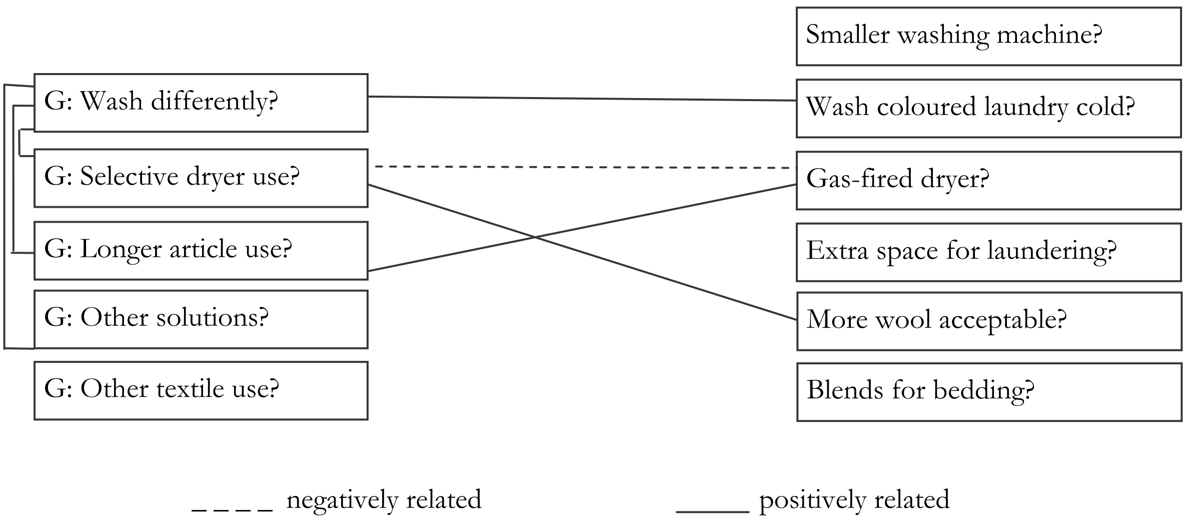


Figure 4.1 *Relations between the responses to five general and six single reduction options (τ_c; p<0.06; n=104)*

A partial correlation whereby dryer possession was kept constant showed that the relations with 'G: wash differently' and 'G: use articles longer' were irrespective of whether a dryer is owned. However, the significant relations between 'G: selective dryer use', and 'wool' and 'gas-fired dryer' disappeared. One relation became significant: between 'extra space for laundering' and 'smaller washing machine' (τ_c = -.23; p=0.03).

One implication of these results is that when aiming for energy savings for laundering, washing differently (including washing coloured laundry cold) and longer article use in general can be addressed simultaneously. When households have a dryer, also selective dryer use can be included. The gas-fired dryer needs to be addressed separately.

4.8.4 Factor analysis of the reduction options and the related variables

To gain more insight into the complex relations between the single and general reduction options and determining variables, a factor analysis with 29 variables was performed (Appendix 4D). For this, the variables used correlated to more than one reduction option and had the highest values for Kendal's τ_c (Table 2 of Appendix 4C). The reduction options 'smaller washing machine' and 'G: other textile materials' were omitted, as they were not significantly or only slightly related to other variables. The significantly related variables measured facts, practices, or attitudes.

In total, nine reduction options were included. Of the other 20 variables, four were demographic (social economic status of the partner/man; education of the respondent, religion, household size). Eight variables involved practices: dryer possession; total kilos of laundry; using energy-saving light bulbs; combining household tasks; heating the space used for drying; number of days that towels and cotton and woollen jumpers are used. Seven involved opinions, beliefs, wishes, or attitudes: laundry would dry without a dryer; selective dryer would be possible; a wish for a dryer in the future; run lines were a reason to buy a dryer; how large extra space for laundering should be, as well as on which storey and whether it has a dryer. The 20th variable involved wash temperature changes in the past.
A factor analysis with these variables was carried out. The initial analysis resulted in ten factors with an eigenvalue >1; however, the scree plot showed a horizontal slope from the eighth factor onwards. The increase in the explained variance of the ninth and tenth factor was less than 3 percent each. It was decided to repeat the analysis with a maximum of eight factors. The Bartlett's test of sphericity (for identity or strength of the relationship among variables of the correlation matrix) had a high value (980.096; significance .000), so the hypothesis that the correlation matrix is an identity could be rejected. The measure for sampling adequacy, the Kaiser-Meyer-Olkin measure, was .703. The result of the factor analysis was thus eight factors with an eigenvalue >1, R^2=65 percent.

The factors are described in more detail in the following:

- Factor 1: 'Selective dryer use is possible', explained 18 percent of the variation and included the most variables compared to the other factors. The variables and relations in the factor were—not surprisingly—related to whether a dryer was owned. This fact did not influence the relations within the other factors. The correlations showed that the people subscribing to more selective dryer use, despite the fact that the number of run lines was a reason to buy a dryer, less often had a wish for a dryer in the future. They had less laundry and wore, for instance, woollen jumpers longer;

- Factor 2: 'Social status and use of articles' explained 9 percent of the variance; education of the respondent, SES of the partner, and use time of towels and jumpers score high on this factor;
- Factor 3: 'Wish for special space' combined characteristics (size and store) of a space for laundering with the wish for such a space;
- Factor 4: 'Flexibility' combined changes in temperature in the past and a possible switch to using more wool; these were positively related and probably reflect positive experiences with previous changes and a certain kind of willingness for flexibility in washing procedures;
- Factor 5: 'Uncomplicated wearing, washing and drying', combined four options (G: use articles longer, G: wash differently, wash coloured laundry cold, and interest in a gas-fired dryer), and the practice to combine household tasks while laundering. Subscribing to the four reduction options was negatively correlated to the practice to combine household tasks;
- Factor 6: 'Reasons for amount of laundry' combined demographic variables that had consequences for the amount of laundry: the household size, the related amount of laundry, and religion;
- Factor 7: 'The dry space is heated' was isolated. Heating of the dry space was not highly correlated to the amount of laundry but to an increasing social-economic status of the woman;
- Factor 8: 'Other solutions' combined two reduction options and a practice: namely 'G: other solutions', 'thought of blends' and, positively correlated, the practice of using energy-saving light bulbs. This latter variable was included, as it could be seen as representing the broader concept 'environmental awareness'.

Five out of eight factors were related to different reduction options. Three reduction options were not clustered with other options. These three options were selective dryer use, wish for special space, and use more wool (respectively, factor 1, 3, and 4). The other reduction options were combined in two factors. These options were: 'coloured laundry cold'/'G: wash differently'/'G: use articles longer'/'gas-fired dryer' in factor 5 and 'thought of blends'/'G: other solutions' in factor 8. The results confirm those in Figure 4.1, that 'G: wash differently', 'wash coloured laundry cold', and 'G: use articles longer' can be addressed simultaneously, but now including the gas-fired dryer. The results of this factor analysis showed that 'selective dryer use' and 'use more wool' need to be addressed separately and that 'blends' and 'other solutions' can be combined. The result of the factor analyses shows eight factors that should be taken into account when trying to achieve energy reduction in the activity category Textile Care.

4.9 Interrelated variables between behaviour and options

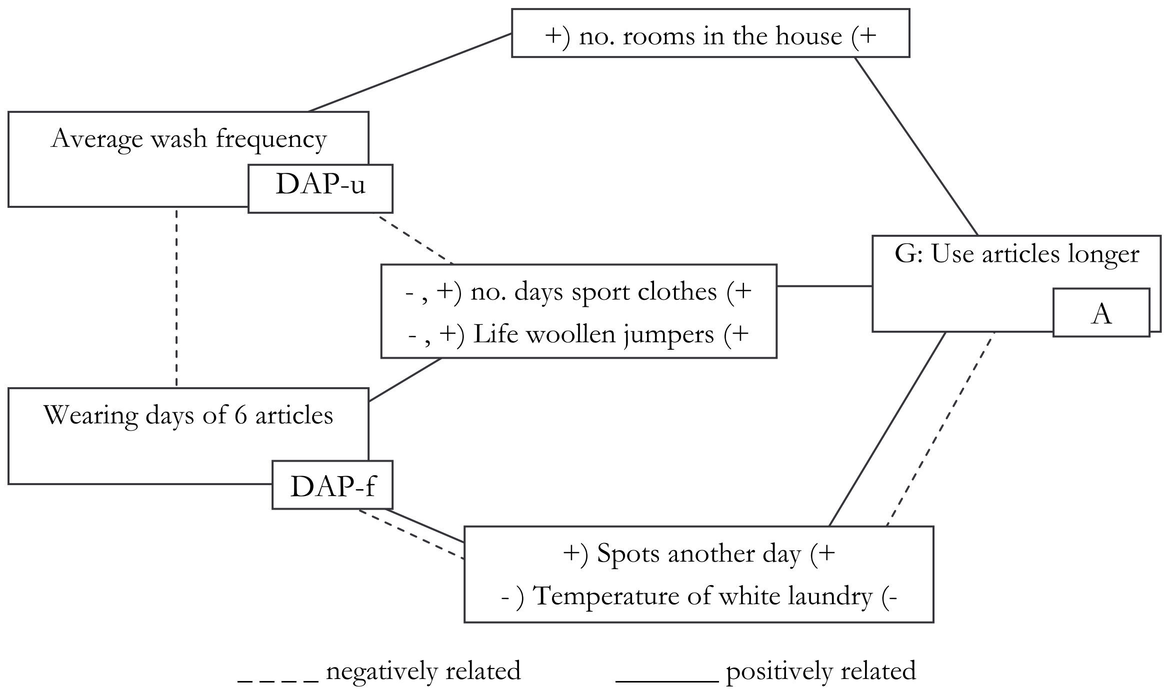
After an examination of the direct relations between behaviour and the acceptance of related reduction options, the indirect relations are investigated in this section. Because a quarter of the behaviour-option pairs were related (§4.8.2), it was expected that the other pairs were related in an indirect way as well.

The aim was to find determinants that affected both behaviour and the acceptance of reduction options. As previously formulated, a determinant is a factor that determines variances in behaviour. Preferably factors are found that can be used to determine the variation deliberately and in a predictable manner when using an intervention. Between the distributions of two variables in a sample, at the most a statistical significant relation can be found that can be used to form hypotheses about causality. Variables related to both behaviour and acceptance are called 'interrelated variables', to distinguish them from other determinants. The causality was examined by reasoning, using the relations within the laundering process as described in §4.7 and the open answers to single and general reduction option questions.

In the following, first the interrelated variables of six behaviour-option combinations of longer wearing, lower wash temperatures, more space for laundering and drying, gas-fired dryers, more selective dryer use, CO/PE bedding and more wool, respectively, are described. The options are labelled A (Acceptance) in Figure 4.2-Figure 4.7. Reduction options in this survey are formulated such that 'more' means less energy requirement. The behaviour (Domestic Actual Practices [DAP, see Chapter 2]) can be increasingly energy friendly when it increases (characterised as DAP-f) or is increasingly energy unfriendly (DAP-u). Only the significant relations are shown (Kendal's τ_c $p<.05$). Negative relations are depicted as dotted lines, positive relations as uninterrupted lines. The hypothetical consequences and content of strategies for interrelations that appear to be causal were thought through. Demographic variables were excluded, as they are less suitable for interventions. The results are described in a more theoretical way and the interrelated variables between more widely defined behaviour-option pairs (e.g. wash temperatures-dryer possession) are also described.

1. Use time of textile articles and longer article use

As described in §4.7 and §4.8, the number of wearing days of six articles and wash frequency were negatively related. Neither were significantly related to the acceptance of the reduction option 'G: use articles longer'* (see Figure 4.2).



** 'Wearing days' is 'parabolic' related to 'G: use articles longer', see Table 4.12*

Figure 4.2 *Wash frequency, wearing days of six articles, the reduction option G: use articles longer, and interrelated variables*

The plusses and minuses in Figure 4.2 can be read in descending order and as follows: ' - , +) no. days for sport clothes (+' means that the number of days that sport clothes are worn is negatively correlated to wash frequency. It is positively related to wearing behaviour and to the reduction option 'G:'. Reading Figure 4.2 from top to bottom:

- The number of rooms was positively related to average wash frequency and G: use articles longer. An increase in the effect of the number of rooms needs 'practical support' to prevent an increase in washing frequency. Respondents were not aware of the influence of number of rooms, as the open answers to the reduction option were not related to rooms or to space. The number of rooms in a house was in fact related to household size, not to using a room specifically for laundering or to average space per person. Household size was not related to wearing behaviour or to willingness to change wearing behaviour. Apparently a higher number of rooms have, besides a relation with household size, an increasing influence on both wash frequency and willingness to use articles longer. This means that the practical support to reduce the effect of a higher number of rooms could consist of strategies to lessen housework, including laundering, by longer wearing and hanging clothes out to air. With a smaller house, confirmatory information could be given;
- Two variables were significantly correlated with wash frequency (DAP-u; negatively related), wearing days (DAP-f; positively related), and the related reduction option (positively related). These were the number of days that sports clothes are worn and the

life of woollen jumpers. Assuming that these relations were causal, the variables need to be increased in order to achieve energy saving;

– A higher average wash temperature for white laundry was negatively related to wearing days and to the reduction option to use articles longer. The influence of white wash temperatures seemed to reflect a rigid attitude to laundering and likely included hygiene. This was confirmed by the significant relations of white wash temperatures to other variables that included a hygienic aspect, such as number of using days of bedding (τ_c -.159; $p<.05$) and leaving clothes for some days and then wearing them again (τ_c -.168; $p<.05$). Many answers to the question 'G: use articles longer' were also related to hygiene. For households that do not wear stained clothes for an extra day and who have a high white wash temperature (τ_c -.171; p.010), information could be given on the use of stain pre-treatment. This might increase confidence that stains can be removed and white wash temperatures can be lowered.

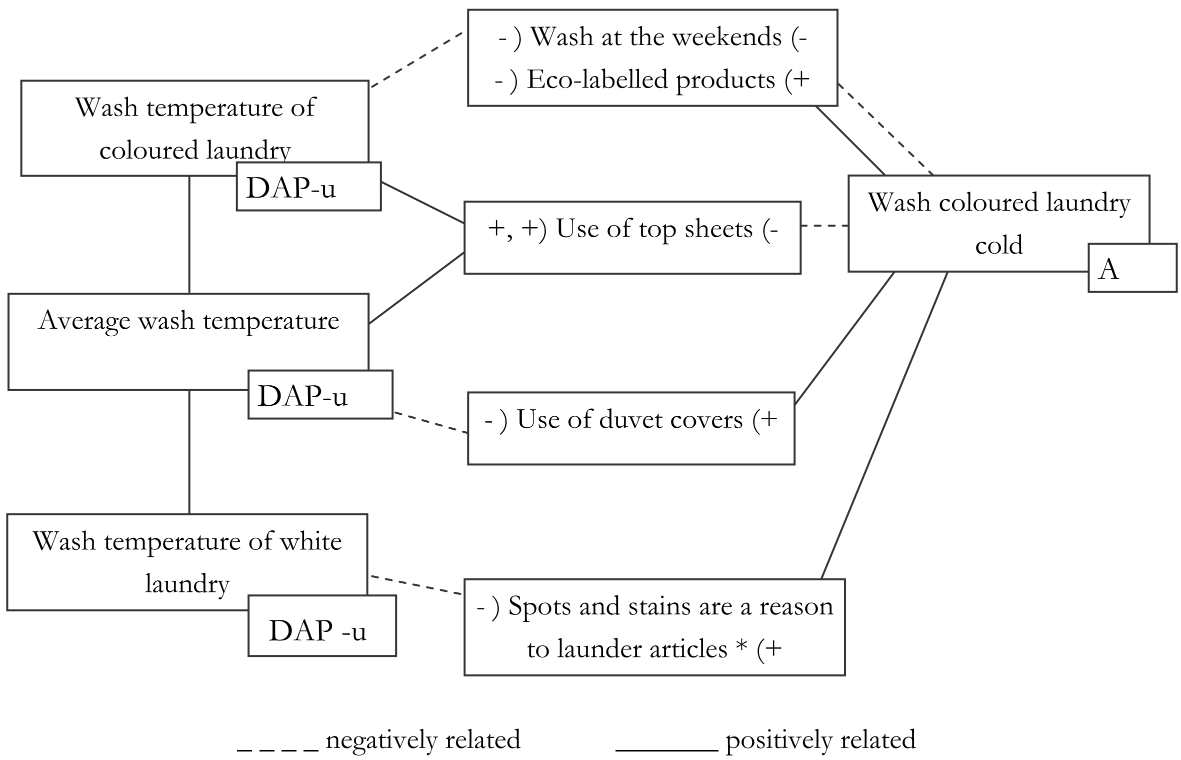
None of these interrelated variables (those related to both DAP and A) were part of the regression analyses for wearing days or for wash frequency. Only wearing days of sports clothes and white wash temperature were part of the regression analysis for acceptance to use articles longer. The implication is that with this method related and interrelated variables are found that are different from those found when analysing what causes behaviour or willingness to change. This is likely to generate further research as well: for example, to examine how the relation between wearing habits and wash temperatures for white laundry is affected when either of these variables change.

2. Wash temperatures and washing coloured laundry cold

The average wash temperatures were not significantly correlated to the acceptance to change the temperature for coloured laundry. Five significantly related background variables were found. Assuming causal relations:

– 'Wash at the weekends' was related to lower wash temperatures for coloured laundry but also to less willingness to wash coloured laundry cold. In addition, it was related to dryer possession and use as well; thus, affecting the habit of washing at the weekends would have an effect on wash temperatures and dryer use;
– 'Buying eco-labelled products' and 'use of duvet covers' had a negative relation to behaviour and a positive one to the reduction option. Thus, increasing these interrelated variables will have a positive energy reduction effect in two directions;
– The 'use of top sheets' and when 'spots or stains are a reason to launder articles (*coded negatively)' related positively to the average and to the white wash temperature and negatively to the acceptance of washing coloured laundry cold.

Washing at the weekends was part of the regression analyses of average wash temperature for white and of the reduction option to wash at lower temperatures. There were no indications that washing at the weekends was related to paid jobs during the week, nor any relation to amount of laundry. Washing at the weekends was related to higher dryer possession (τ_c .232; p.019), lower acceptance of washing coloured laundry cold (τ_c -.186; p.021), less space per person (τ_c -.216; p.015), and of course a lower temperature for coloured items. Hence, the reasons for washing at the weekend and using a dryer were not related to jobs or to the amount of laundry. It is not clear why less space per person would lead to more washing at the weekends. Probably a well-thought out message on planning, spreading laundering throughout the week, temperature choice, and space use could support lower temperatures as well as selective dryer use.



** coded negatively*

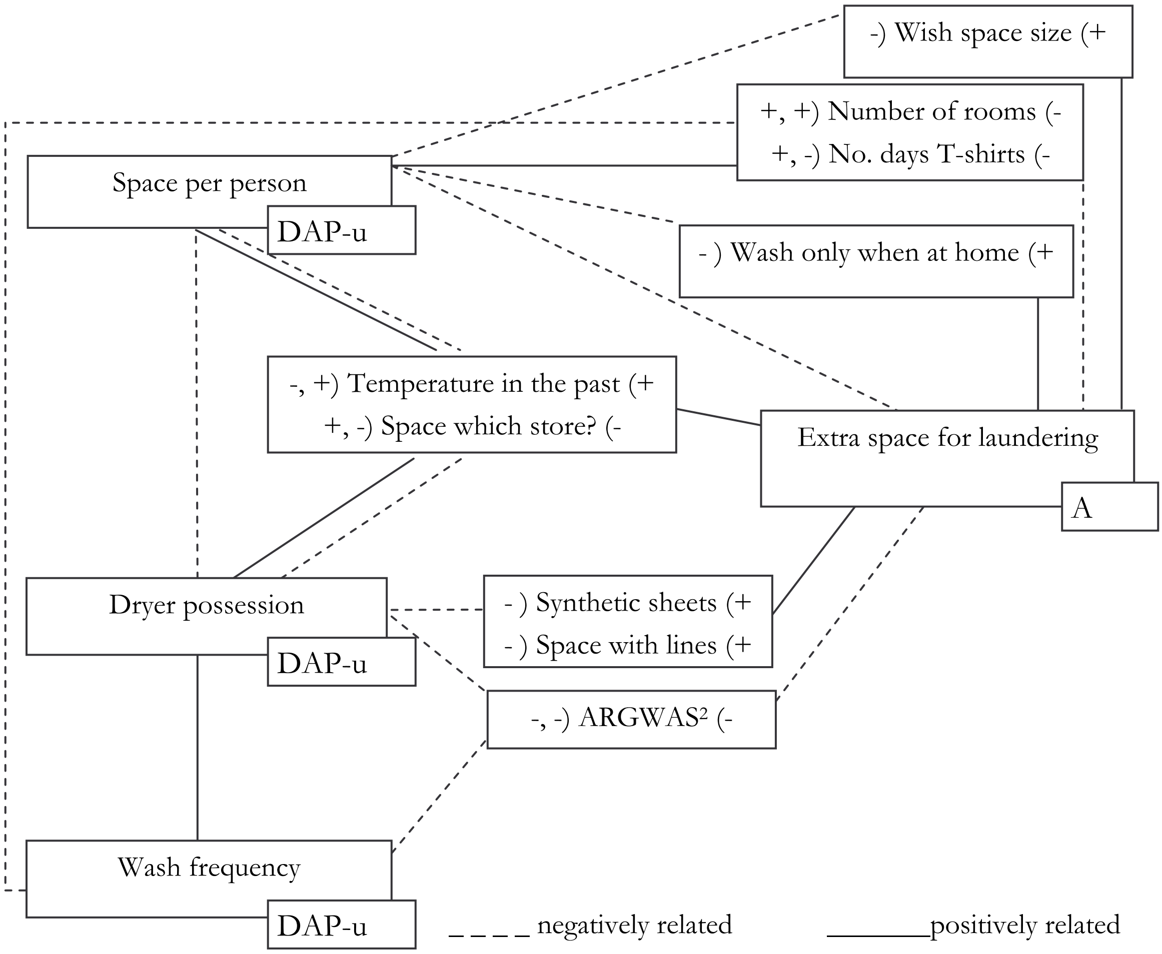
Figure 4.3 Relations between wash temperatures and the reduction option 'wash coloured laundry at 25ºC'

The use of top sheets is no longer common. Ten of the 104 households used top sheets, while the others used duvet covers. Their use was also part of the regression analysis of average wash temperature. Thus, promoting the use of duvet covers is helpful to reduce average wash temperatures. When top sheets are continued to be used, coloured or synthetic top sheets can be promoted instead.

'Spots and stains as an argument to launder' was also part of both regression analyses for white wash temperatures and for the reduction option. When spots and stains are important, information on stain pre-treatment, lower wash temperatures ('modern, not necessary to wash at higher temperatures, good for the environment'), and buying less white laundry can be helpful to lower wash temperatures.

3. Dryer possession and extra laundering space

In general, many households claim they do not have enough space to line dry and therefore need a dryer; thus, extra space was seen as a reduction option to replace the tumble dryer. More space per person costs building energy and was therefore classified as DAP-u. Whether the reduction option 'extra space for laundering' is energy efficient depends on the size of the space, future dryer ownership, dryer use, and the use of clotheslines.



[2] *Coded negatively*

Figure 4.4 Dryer possession, space use, and the desire for extra laundering space

First the interrelated space variables are discussed:

- With more space per person, extra space for laundering was less often wanted and dryer ownership was lower. None of the variables, such as amount of laundry, wash frequency, or household size were part of the interrelated variables. More space per person and more overall space were negatively related to the wish to have extra space for laundering, and not so much to the use of space, including laundering and household size. The results show that more space is indeed an alternative for tumble dryer possession;
- Decreasing space per person was related to an increase in the need for a dryer and to the wish for extra space. Decreasing space per person could benefit from confirmatory information about how to cope without a dryer, about the energy friendliness of line

drying, and about how to reduce the feeling of lack of space by creating solutions for line drying laundry;

- Three of the interrelated variables were related to what the extra space for laundering should look like. These were 'wish space size', 'space which storey', and 'equip extra space with clotheslines'. The last two were related to dryer possession. It is necessary to choose between whether to decline dryer possession or a space on the ground floor. Perhaps finding a better spot for line drying and a well-designed indoor space on a higher storey, possibly close to an outdoor space suitable for line drying, could help to decrease dryer ownership;
- Households that had a dryer and that had a wish for extra space for laundering, or already had extra space, had a pronounced preference for the ground floor as the location of extra laundering space. Only households with more space per person did not mind on which storey the extra space is located. Preference for the ground floor was significantly related ($p<.05$) to the greater importance of arguments to launder, to more interest in a gas-fired dryer, to a dryer in the future in general, and to more household members and children living in the house. The type of house was also instrumental: Households that lived in a detached house had a preference for the ground floor, and this preference was even stronger for households that lived in a terraced house. After all, the ground floor location seems relatively environmentally unfriendly because of the related wish for future dryer ownership.

Other variables that linked wash frequency and the reduction option 'extra space' were 'the number of rooms' and 'the number of days that T-shirts are worn'. When they increased, the wish for extra space decreased.

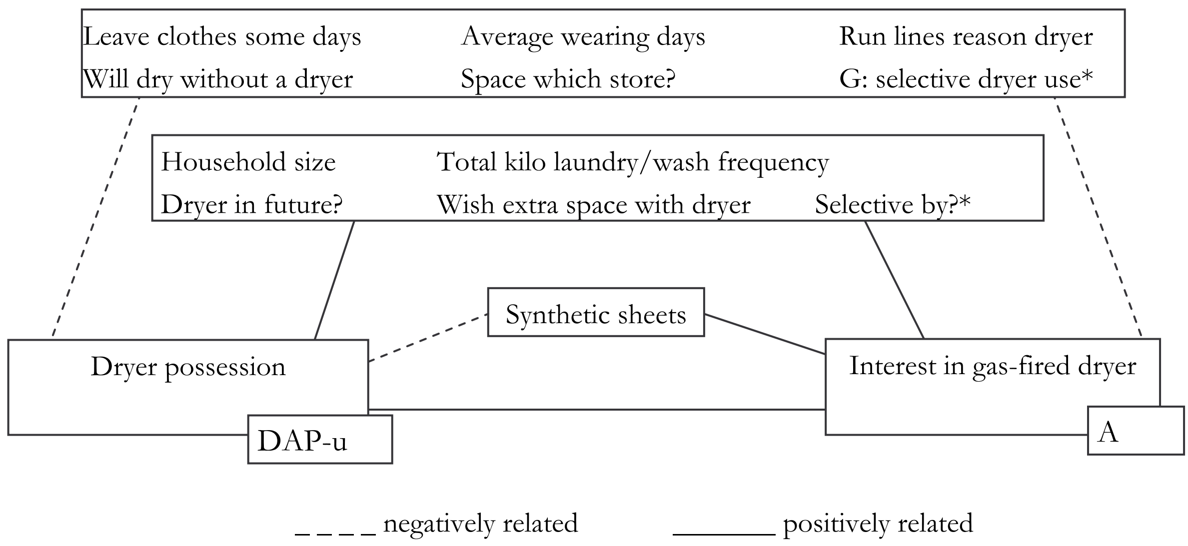
Other interrelated variables are briefly mentioned:

- The use of synthetic sheets (in relation to dryer possession) was a variable that had positive effects. Encouraging the use of synthetic sheets would cover another reduction option: Because of the lower absorption rate, less energy is needed for drying;
- When respondents did not stay at home when the washing machine is on and when more space per person was available, there was less desire for extra space. This was also indirectly related to less dryer ownership and to a lower wash frequency. So it might be a good idea to discourage spending time on household tasks (staying at home and doing a lot of laundry) and to encourage doing laundering throughout the week so that hanging out the washing is possible.

The other variables (past temperatures and arguments to launder) did not provide causal reasons upon which to elaborate.

4. Dryer possession, selective dryer use, and gas-fired dryers

Dryer possession and interest in a gas-fired dryer were related to 12 variables, in particular the reasons for the amount of laundry.



** For dryer owners*

Figure 4.5 Relations between dryer possession and interest in a gas-fired dryer and other variables

The interrelated variables in the upper box had a negative relation to both dryer possession and to the wish for a gas-fired dryer. When these interrelated variables increase or are applicable, households could benefit from confirmatory information about the advantages of not having a tumble dryer. However, when households do not leave clothes and have a short average wearing time of clothes, do not think that laundry can dry without a dryer, and are not willing to use the dryer selectively, they could benefit from practical information. This could include that 'increasing wearing days', 'leaving clothes for some days and wearing them again' and 'selective dryer use' are an alternative to a tumble dryer or a gas-fired tumble dryer.
The variables in the middle box were all positively related to both DAP and A. When these variables increase, measures basically come down to practical tips to reduce the amount of laundry or to information about gas-fired dryers. No action is needed when these variables decrease or do not apply.

Due to their shorter drying time, synthetic sheets can be promoted to reduce dryer ownership.

Selective dryer use was not distinctively present in the results, except in relation to gas-fired dryers. This implies that selective dryer use is more a reduction option on its own; it only worked as an interrelated variable in relation to a gas-fired dryer and in this case it reduced the need for a tumble dryer as well as a gas-fired dryer. Interrelated variables between selective dryer use, such as for white loads and for fine/synthetics loads and using the dryer as often in the summer as in the winter, and the willingness in general to use dryers selectively ('G: selective dryer use'), were 'partner away from home extra hours', 'weight of the wash load' and type of washing machine. See also §4.11 for an indication of the relevance of these variables.

5. Bedding of cotton/polyester blends (CO/PE)

The use of iron-free sheets—or of any other kind of bedding and bedding materials—and the acceptance of CO/PE bedding were not related. As regards bedding article types, the use of iron-free sheets was the only one that had a variable with acceptance of CO/PE in common. Most households that used top sheets (n=10) indicated that these were made of cotton. Iron-free sheets could be made of cotton as well (apart from blends), which was treated with a special finish. Therefore the use of iron-free sheets was seen as DAP-u, as these sheets are no different from normal cotton ones. The use of top sheets, in particular when made of CO/PE, has a positive effect on energy saving and can be supported.

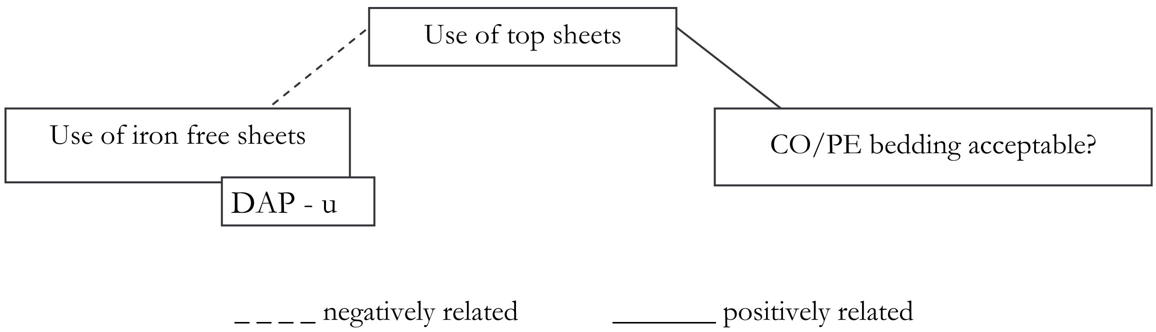


Figure 4.6 Use of bedding materials, acceptance of other materials, and interrelated variables

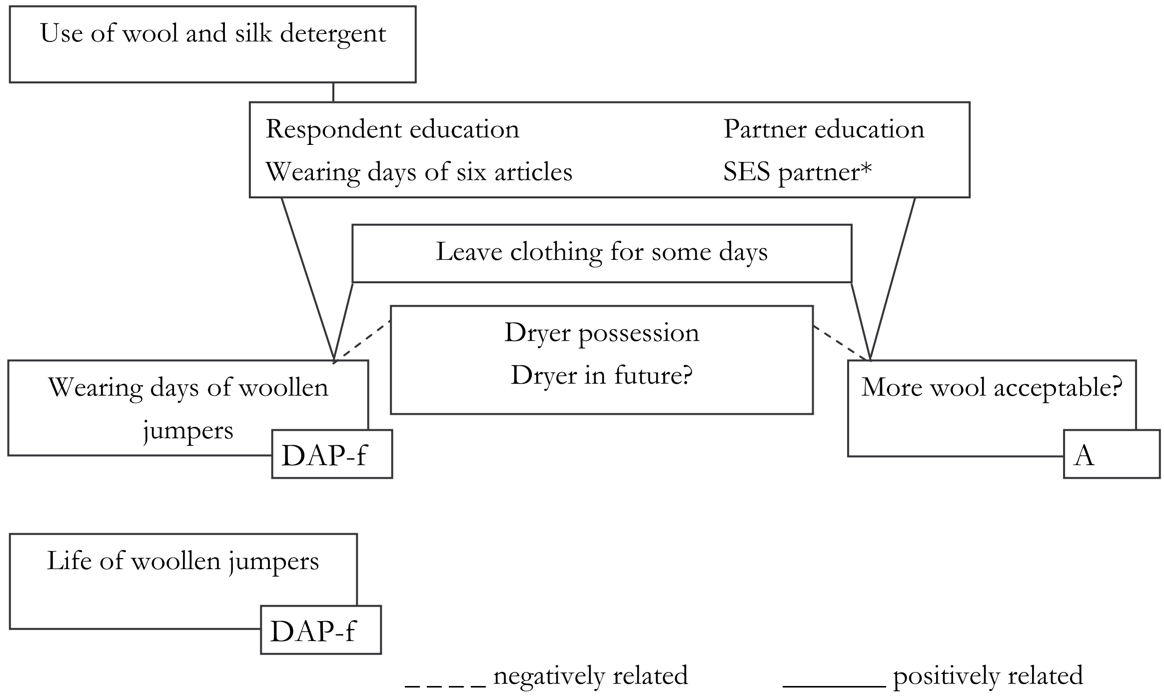
When top sheets are replaced with CO/PE sheets in combination with the use of duvet covers, which was done by 3 percent of the households, this might save laundry as well because the duvet covers can be washed less often.

6. Use and further use of wool

Whether woollen articles were used was restricted in the questionnaire to the wearing days and the life of woollen jumpers. Seven variables were correlated either positively or negatively with how many days woollen jumpers were worn and whether more wool was acceptable.

- Of these variables, five were positively related, among which was the education level of both respondent and partner. Regarding the partner's socio-economic class, which was coded negatively, the higher the class, the higher the number of wearing days, and the more acceptable the increased use of wool.
- Two interrelated variables were negatively related to both DAP-f and A: dryer possession and the wish for a dryer in the future.

Households that could possibly benefit from confirmatory information are ones that do not possess a dryer and do not want one in future, who use wool for longer periods both in wearing days and in the lifetime of the item, and who use a detergent appropriate for wool and silk.



** coded negatively*

Figure 4.7 Relations between aspects of wool use and whether more wool is acceptable

Lower education- or low-SES households with a dryer or that want a dryer in future, that wear wool for only a few days at a time, and that do not use-detergents for wool and silk can be informed about how to wear and how to maintain wool. This information deals with the status, the quality, and the attributes and advantages of wool, such as less dryer use and less laundry when wool is handled properly.

Measures and strategies based on the interrelated variables

Along with the previously mentioned interrelated variables, suggestions for changing laundering behaviour in order to save energy were described in the previous paragraphs. The proposals described in this section thus far can be further re-grouped:

Firstly, space and the use of space and wool are related to the amount of laundry and dryer possession:

1. Space
- Practical support to reduce the effect of a large number of rooms is to offer strategies for decreasing housework, including laundering. For instance, clothing can be worn longer by breaking up the wearing periods. Confirmatory information about not having a dryer can be useful when households have a lot of space.

- Households in a smaller house and with less space per person can also be given confirmatory information on laundering practices that reduce the amount of laundry. In addition, practical information and mental support can be provided on how to cope with not owning a dryer and how to reduce the feeling of shortage of space by creating solutions for line drying laundry. Helping to find a better spot for line drying and designing a suitable indoor area close to an outdoor space for line drying might help to avoid dryer ownership.
- Practical information that increasing wearing days, leaving clothes for a while and then wearing again, and selective dryer use can be an alternative to a tumble dryer; households can also benefit from information about gas-fired dryers as an alternative to an electrical tumble dryer.

2. Wool
- Households can be informed about how to wear and to maintain wool, about the status, quality, and other attributes of wool and its advantages, such as less use and need of a dryer and less laundry when wool is handled properly. Households that already use wool can benefit from confirmatory information about its use and the relation to less laundry and less need for a dryer.

Secondly, stain pre-treatment, bedding, and planning are related to wash temperatures and dryer use.

3. Stain pre-treatment
- When spots and stains are important reasons to launder, information can be given on the use of stain pre-treatments, which might increase confidence that stains can be removed and that white wash temperatures can be lowered (also 'modern, not necessary to wash at higher temperatures, good for the environment'). Moreover, buying less white laundry can be helpful to lower wash temperatures.

4. Bedding
- Promoting the use of duvet covers is helpful to reduce average wash temperatures. When top sheets are used, whether in combination with duvet covers, coloured (synthetic or CO/PE) top sheets can be promoted. Because of the shorter drying time for synthetic or CO/PE sheets, their use can decrease dryer ownership. When used in combination with duvet covers, this might save on laundry as well because the duvet covers can be washed less often. The sheets have a single layer, so less material to wash.

5. Planning of laundering
- Lower temperatures, a lower wash frequency, lower dryer ownership as well as selective dryer use can be supported by a well-thought out message on planning, discouraging time spent on household tasks, spreading laundering throughout the week, and temperature choice.

Although in 66 percent of dryer owners in this case study said that lack of space was the reason they used a tumble dryer, the relations to space are more complex:

– It was found that the wish for extra space was related to future dryer possession, although no indications were found that dryer use would increase, because clotheslines were preferred as well. Extra space for laundering was not such a good reduction options after all, because it would require indirect energy and would lead to more people owning a dryer.
– It was found that more space was related to less wash frequency, dryer possession, and washing at the weekends. The question is what saves more energy: less space on the one hand or a lower wash frequency and dryer possession on the other hand.
– When space per person decreased, both dryer possession and the wish for a special laundering space increased, which is indeed an indication that they might be interchangeable. It was found that *use* of space, including laundering and household size, were not related to the wish for extra space. Therefore it is questionable whether only practical advice to reduce the amount of laundry and to cope with lack of space would stop people wishing for extra laundering space. It is likely that planning advice would help.

Planning advice could consist of, for example, 'leaving clothes for some days and then wearing them again', 'airing', and laundering regularly during the week instead of just laundering when the basket is full or at the weekends. Better planning of the use of space or changing the perception of the available space can provide mental support to drop the wish for a dryer or for more space and could encourage energy-saving practices, such as selective dryer use and a reduction in the amount of laundry.

To include actual household behaviour in research about behavioural change, and to look for interrelated variables, results in additional suggestions for saving energy. The interrelated variables can be seen as ones that are *influenced* (and thus have to be taken into account for, e.g. rebound effects) or that can *influence* (and, assuming that the relations remain when the variables change, can be used in interventions).

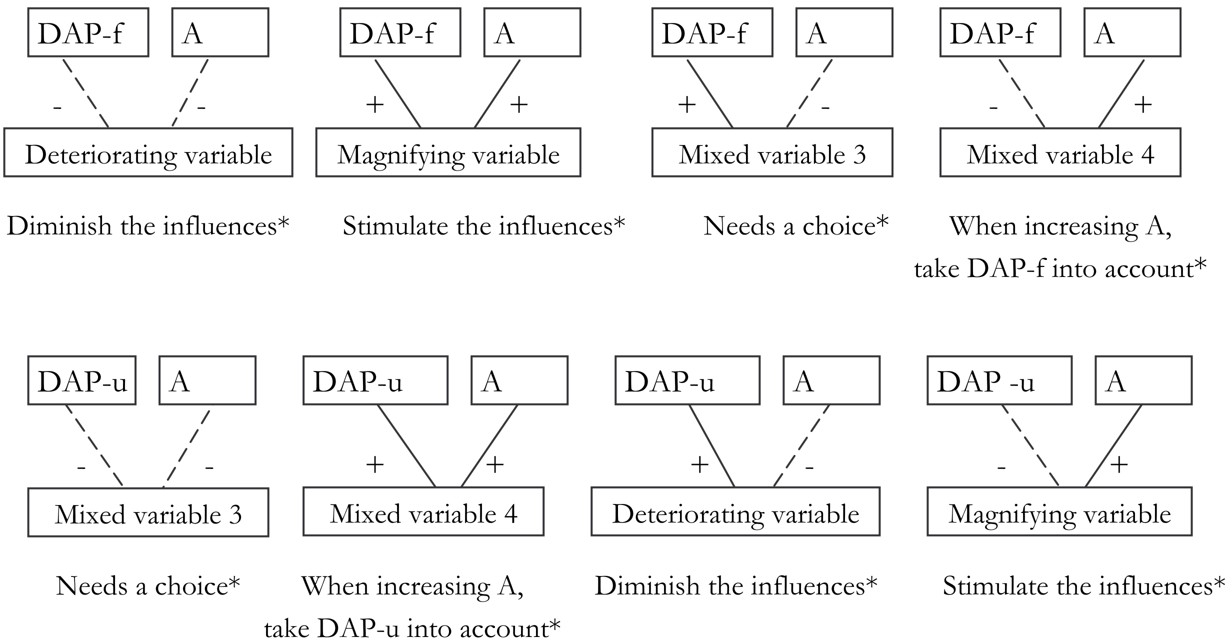
It is not advisable to change attitudes about laundering or to reduce the importance of hygiene. It is likely that a distinction can be made between practices that are really necessary for hygiene, such as wash temperatures on the one hand and practices that are more related to 'proper' laundering or appearance on the other hand.

4.10 The 'interrelation' approach more widely applied

Theoretical description

The above approach to finding and describing interrelated variables can be described in a more structural manner. Depending on whether DAP is energy-friendly (f) or unfriendly (u) and whether increasing interrelated variables are positively or negatively related to DAP and A, eight situations and four kinds of interrelated variables (or the strategy that can be deducted) can be distinguished (see Figure 4.8). The upper row in Figure 4.8 represents DAP-f; practices that lead to energy saving when the practices are increasingly applied. The lower row represents practices that lead to increased energy consumption (DAP-u) when increasingly applied. The reduction options in this survey are formulated such that 'more' means less energy requirement.

The four kinds of interrelated variables between both practices and acceptance have, assuming that they increase, the following effects: (1) deteriorating, (2) magnifying, (3) stimulating energy-friendly behaviour (or reducing energy-unfriendly behaviour) and diminishing acceptance, and (4) stimulating acceptance and diminishing energy-friendly behaviour (or stimulating energy unfriendly behaviour [mixed variables]). This will depend on their relation with DAP and with the A, see the + or – signs in Figure 4.8. Assumed is that the effect on DAP can be influenced by practical support and the effect on A by social-psychological/mental support. The effects of the interrelated variables can then be translated into energy saving measures.
The influences in the configuration in which the deteriorating interrelated variable is involved need to be *diminished* using both practical and mental support. The configuration in which the magnifying interrelated variable is involved needs to be *stimulated,* again using both practical and mental support. For the configuration in which the third and fourth kind of interrelated variables are involved, a *choice* is needed whether to focus on the effect the interrelated variable has on DAP or on A. This can be done in two ways, either *using the relations* that already exist or by measures that have an effect on the relation.



Items marked by an asterix (*) imply where to go for advice and for measures to achieve energy reductions when causal and dynamic relations are assumed.

Figure 4.8 Interrelated variables between Domestic Actual Practices (DAP) and Acceptance (A)

The formulation of the actual behaviour and interrelated variables exercises a major influence on which advice and suggestions will be generated.

Application to more widely defined option-behaviour pairs

To find variables that are related to laundering and changes in laundering in general, interrelated variables were also searched for in non-related behaviour and reduction option combinations. These combinations consisted, for example, of responses to the reduction option 'washing coloured laundry at 25°C' and the behaviour 'number of storeys used for laundering'. Each variable that is related more than once to both behaviour and the answers to reduction options is shown in Table 3 of Appendix 4C. These variables can be seen as not specifically, but nevertheless significantly related to both laundering and to willingness to change laundering in general.

This set was compared with the sets of variables that are related more than once to laundering behaviour and to the responses relating to reduction options (see Table 1, set 1, and Table 2, set 2, Appendix 4C).

These three sets are shown in Figure 4.9. The first is a set of variables that are related once or more with the variables for laundering. The second set consists of variables that are correlated more than once with two or more answers relating to reduction options. The third set consists of variables that are interrelated more than once.

- Set 1, 2, and 3 overlap with 17 variables. Three are related to demographic or household variables (SES, SESV, household size), and three are related to the actual situation (amount of laundry, dryer possession, and number of days woollen jumpers are worn). Amount of laundry is more or less interchangeable with wash frequency and the number of days textile articles are used. One variable involves wash temperature changes in the past. Six are related to dryer wishes: Were run lines a reason to buy a dryer? Is a dryer wished for in the future? Is an extra space desirable? Of what size? Space with a dryer? Space on which storey? Three variables are related to acceptance to change (G: selective dryer use, selective dryer use by?, interest in a gas-fired dryer). Thus dryer and dryer reduction options are relatively important.
- Apart from these variables, set 1 and 3 also overlap with a large number of variables. Set 1 and 2 overlap with the number of days that towels are used, while set 2 and 3 overlap with religion and whether the dry space is heated. For laundering, religion is of minor importance and only significant for temperature choice (not visible in Figure 4.10).
- Set 3 has the most variables that are not part of the overlaps; compared to set 2, set 3 has more demographic and situational variables and more practices, whereas set 2 has more variables that are related to flexibility or inflexibility in change. This shows that the nature of variables is different when one searches for determinants with a wider perspective than when looking for the variables that are related to willingness to change.
- More important for the acceptance of reduction options than for laundering are 'combining household tasks', 'use of energy-saving light bulbs', and 'will dry without a dryer'. Together with the use of softeners, which has not yet been discussed, these variables might be representatives of other concepts, such as the importance of the results of laundering or a practical form of environmental awareness.

It is concluded from Figure 4.9 that the variables are related to behaviour and to the acceptance of reduction options both in a specific and in a wider behavioural change context. Several variables can be found in the overlaps between set 1 and 3 and set 1, 2, and 3. Laundering and the acceptance of reduction options share more than a third of the relevant determinants.

The three sets were used to distinguish which indicators actually determine laundering, including willingness to change. This led to a different set compared to the energy indicators as described in §4.4 (see Table 4.14). These determinants are called laundering indicators. Compared with energy indicators, this set of variables describes in a more practical way the influences on laundering within the activity category Textile Care. It is expected that the laundering indicators will predict more accurately the energy consumption of laundering and will be suitable for communication with households about energy saving.

Table 4.14 Laundering indicators based on determinants of behaviour and willingness to change

Laundering indicators based on determining variables of behaviour and willingness to change
Textile use (use days, leave clothes for some days, only new clothes, arguments to launder)
Amount of laundry/wash frequency
Wash temperatures (earlier changes)
Available space/space use
Dryer possession and related wishes (extra space, run lines, future dryer, gas-fired dryer)
Drying (selective loading, heat dry space)
Bedding (type and material: duvet covers, top sheets, synthetic sheets)
Wool use
Planning of laundering (at night, weekends, combine household tasks, when basket is full, influence of family members)

In addition to these laundering indicators, demographic variables (SES, education, the respondent having a job, age, religion, and household size) influenced changes in laundering.

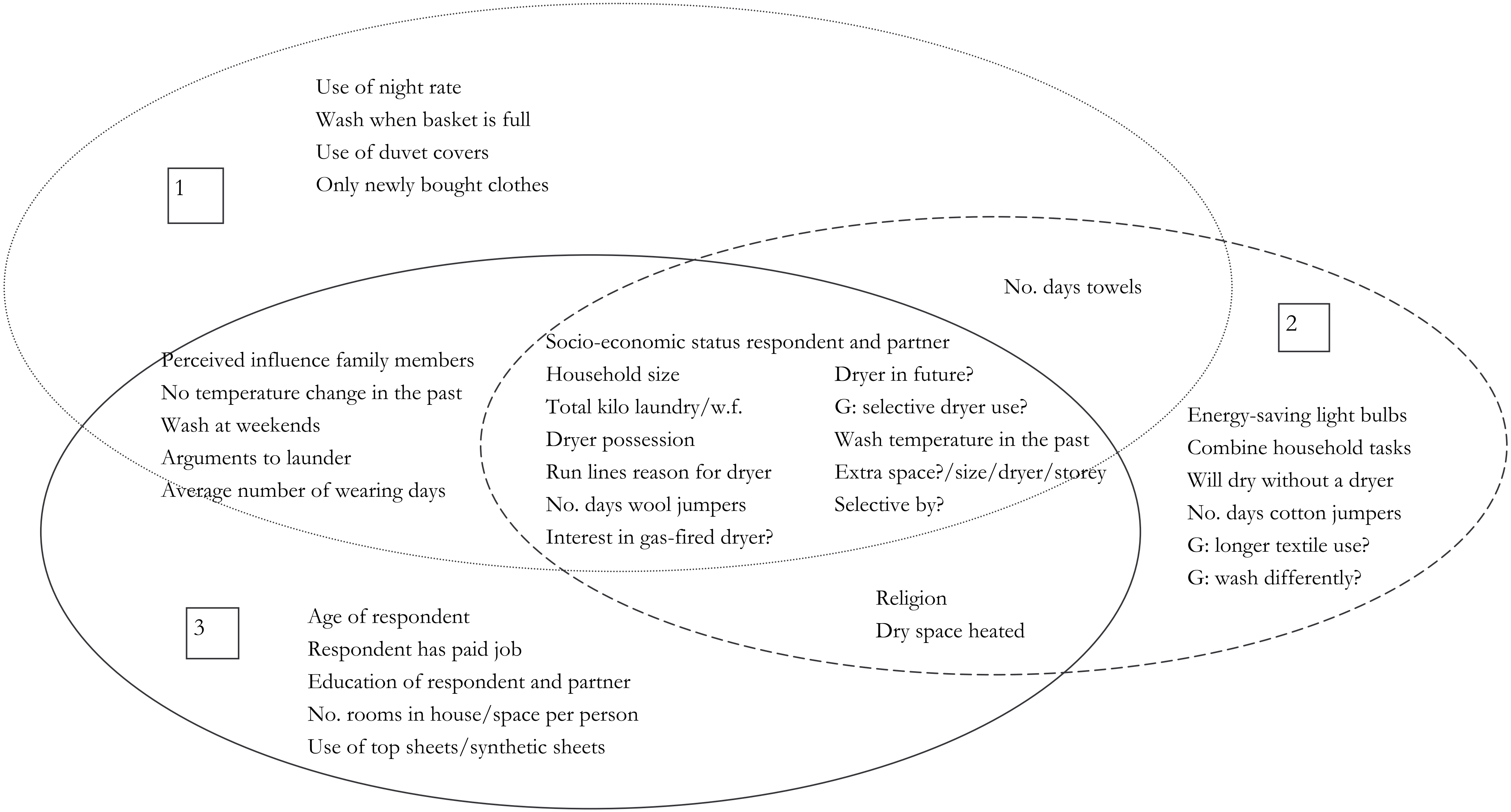


Figure 4.9 Overlap of variables often related to laundering practices (set 1) and to responses to reduction options (set 2), and of interrelated variables (set 3)

4.11 Domestic energy-saving potential

In this section, the energy savings are calculated by taking into account the actual practices as well as the percentages of households that respond positively to reduction options. Not only the potential of the six single reduction options are calculated and described but also options that can be derived from the open answers to the general sub-questions about changing laundering, wearing, and use of materials.

Washing coloured laundry at 25°C

Washing at lower temperatures seemed the most promising and feasible energy reducing option. It could save between 7 percent of the washing process in the short term and 9 percent in the long term, the latter requiring measures such as improved detergents or other washing programmes. These options were derived from 13 percent of the households that spontaneously mentioned that they could wash at lower temperatures to help save the environment. For the first short-term option it is assumed that 13 percent of the households in each temperature category *shift* to one temperature category lower and that this 13 percent can be applied to the number of wash cycles (on average 379 cycles/hh.y). Therefore, 13 percent of the loads in each temperature class are washed in a class lower, leading to the following shift in the temperature distribution of laundry cycles (rounded to .5):

at 70-90°C from	7 percent (26.5 wash cycles/hh.y)
	→ 6 percent (23 cycles/hh.y)
at 50-60°C from	31 percent (117.5 wash cycles/hh.y)
	→ 28 percent (105.5 cycles/hh.y)
at 30-40°C from	62 percent (235 wash cycles/hh.y)
	→ 58 percent (220 cycles/hh.y)
at 25°C	→ 8 percent (30.5 cycles/hh.y)

This would save 7 percent of the energy requirement of washing. This can be seen as a short-term option, probably without a change in detergents and so on. A 25°C temperature can be applied to special laundry that is already washed at low temperatures.

The second and long-term option is based on *answers* given by these 13 percent.
With relation to the general question about washing differently, seven of the 14 respondents who mentioned 'washing at a lower temperature' responded to the single reduction option 'washing coloured laundry at 25°C with 'under conditions'. The other seven said it was 'worth a try'. This implies that half of these households would not shift one temperature class lower as in the previous example, but would wash at 25°C. This assumption is optimistic and results in the following distribution:

at 70-90°C	→	6 percent
at 50-60°C	→	27 percent

at 30-40°C → 54 percent
at 25°C → 13 percent

This would save 9 percent of the washing process but would require measures such as improved detergents, other washing programmes, and targeted information campaigns. Thus, a larger shift in the temperature categories is not proportional to the energy saved.

The willingness to wash coloured laundry at 25°C was not related to households that changed to a lower temperature in the past (n=37), that did not change at all (n=47), or that changed to a higher temperature (n=13). The willingness was also not related to the temperature in general or to the temperature of coloured laundry. This was why the previously mentioned assumptions about shifts to lower categories were used.

Smaller washing machines

What would the load of a smaller washing machine be (capacity 3.5 kg)? The average load of a usual washing machine was 3.4 ± 0.4 kilos, which is 72 percent of the average 4.7 kilo 'usual machine' capacity. Two assumptions are made:

- Households that do not have an opinion about how they will load a smaller washing machine load in the same way and with the same percentage (72 percent);
- Sixteen percent of the households will load fuller, up to the 'average + the standard deviation'= 3.4 + 0.4 = 3.8 kilos (81 percent of the 4.7 'usual machine' capacity).

This means that 16 percent of the households would load a smaller washing machine with 81 percent of the 3.5 kilo capacity (smaller washing machine) and the other 84 percent of the households would load with 72 percent of the 3.5 kilo capacity. This leads to an average load of (0.45 + 2.12 =) 2.57 kilos, 74 percent of the capacity of a small washing machine, which is only slightly higher than the load for a normal washing machine.

In total, five households were positive about smaller washing machines, but only one considered it possible in their particular situation (with children) without having to wash more often. A smaller washing machine is not a suitable option for the group of households represented by the sample.

Higher average loads

The average load per household was 3.4 kg. Theoretically a possibility exists for 3.7 kg (see 2.2.4), thus 0.3 kg more. In the event that all households loaded 0.3 kg more, a reduction potential of 8 percent of the number of washing cycles exists, not taking into account the types of laundry per single household.

In their answers to the first open question about voluntary changes in textile maintenance, 9 percent of the respondents gave options related to fuller loading. These households loaded on average 3.55 kg. In the event these households loaded with 0.15 kg more, from 3.55 kg to 3.7 kg, coincidentally half of the reduction potential, this would save on average 14 cycles per year (3.55 kg*342 cycles = 1214 kg laundry/hh.y; when washed with 3.7 kg loads this leads to 328 cycles per year), which is 4 percent of the numbers of washed cycles per household, and 0.3 percent when the share of willing households (9 percent) is taken into account.

Longer wearing

According to the regression analyses, the longer use of clothing and other articles led to less laundry and to a lower frequency of washing. By dividing respondents into groups with different numbers of wearing days, differences in average wash frequency can be quantified and savings can be examined. For the wearing variable, the sample was divided into four groups of households, with the help of a cluster analysis. The wearing variable consisted of the wearing days of blouses, T-shirts, jeans, sports clothing, and the use of bath and kitchen towels. Bedding and jumpers were excluded, as they undermine the influence of the six other variables: If bedding is used for three weeks it determines the overall variation and dominates the variance in the wearing days of, for instance, blouses. The cluster analysis resulted in a division of four groups. Of these four groups the means for other variables (such as wash frequency) were calculated. To see whether the division into those four groups significantly decreased the variance of other variables and the calculated means differed, a one-way variance analysis was performed with variables such as wash frequency as a dependent variable and membership of the four wearing groups as an independent variable. The results of the cluster analysis and the one-way variance analyses are shown in Table 4.15.

In total, 97 households were included in the cluster analysis. Group 1 has double the number of wash cycles compared with group 3. In short, it can be concluded that when a family use and wear articles *one* day longer this saves 100 cycles a year; this is a quarter of the average number of cycles per year, which reduces by 25 percent the energy needed for washing. This is examined in the following with relation to willingness to use textiles for longer periods.

One-way variance analyses using these wearing groups as the independent variable were performed for a range of household variables as well. The division in wearing groups led to an explanation of the variance for seven variables: the socio-economic status of both the woman and the man, for age, education, professional status, the respondent having a paid job, and the number of available rooms per person (ANOVA $n=104$, $p \leq .05$). For each of the seven variables, a higher value was related to longer wearing.

Table 4.15 One-way variance analyses results and mean values for laundering variables for the groups resulting from the cluster analysis for 'wearing days'

	No. wearing days	Average (day/article)	Frequency (cycle/y)	Load (kg/cycle)	Total laundry (kg/hh.y)	Temperature (°C)	No. members (#/hh)
Mean	14.4	2.4	400	3.4	1294	47.5	4.2
Group							
1 (n=45)	9.3	1.5	495	3.4	1613	48.2	4.2
2 (n=28)	14.6	2.4	378	3.4	1155	46.7	4.5
3 (n=18)	21.9	3.7	271	3.6	909	48.8	4.0
4 (n= 6)	29.5	4.9	197	3.6	702	43.0	3.7
Significance*	.00	n.a.	.00	.41**	.00	.24**	.17**

** One-way variance analyses for laundering variables with membership of the clustered groups as an independent variable*
*** No significant difference*

In the first and largest group the six items were used for the shortest time. Using articles a day longer was connected to a significant decrease in wash frequency and total amount of laundry, with the largest decrease from 1.5-2.4 days. This was not unexpected, as earlier plots showed the reciprocal relation of wearing to amount of laundry. The households did not differ significantly with regard to wash temperatures, although an average difference of 3.2°C (between the groups) and a difference of 5.8°C (between group 3 and 4) seems considerable; the number of households in group 4 was probably too low to be of influence. The number of days that bedding and woollen and cotton jumpers were used differed significantly for the four groups as well (Table 4.16), although for bedding, groups 2 and 3 did not differ greatly.

Table 4.16 Significance of the different mean values for use days of bedding and woollen and cotton jumpers*

Group	Bedding (No. days)	Woollen jumpers (No. days)	Cotton jumpers (No. days)
Mean	10.4	19.6	7.1
Group 1	8.5	5.8	3.1
Group 2	11.5	15.7	4.6
Group 3	11.9	43.5	11.4
Group 4	14.5	66.7	37.7
Significance**	.00	.00	.00

** The groups resulting from the cluster analysis of 'wearing days'*
*** One-way variance analyses for laundering variables with membership of the clustered groups as an independent variable*

The open question as to whether it was possible to use clothing longer was answered with 'yes' by 32 percent (n=32). The group that was not willing to use articles longer used their articles 3 days less (average 13.4) than the group that was willing (average 16.4). Willingness (no/yes) and wearing days were significantly correlated (τ_c= .19; p<.05).

It can be derived from their comments that 12 households (12 percent) would probably not change their wearing behaviour even though they said 'yes'. Three households thought the situation would be difficult to change, four considered that they already use articles for long periods, and two households felt that synthetics needed to be adapted (smells) or that 'bacteria in cotton' was a good idea to make longer use possible. Three household misunderstood the question and said that buying a new set of clothing every half year was not really necessary and that wool and other high quality, long lasting materials should be sold for a reasonable price.

Twenty percent of the one-family households were willing to use their articles longer; eight of them are in group 1, four in group 2, seven in group 3, and one in group 4. Their average wearing days was already 1.3 days longer than the sample as a whole. Fourteen of these 20 households 14 thought of solutions they could apply themselves. These solutions are mentioned in Table 4.17. The other six households thought it would take some time to get used to using articles longer but that it would be possible for them.

Table 4.17 Solutions mentioned by 14 respondents in order to use articles longer before laundering

Solutions	n	Solutions	n
To make children more aware, point it out to them	1	Air more often	3
To prevent stains by using aprons and bibs	1	Wait longer with washing	1
Change more often for different activities	1	Use bathroom towels longer	2
Wear clothing another time on less representative days	2	Just wear them longer	3

Of the other 68 percent, 38 households made no comments, 16 thought they already use their articles as long as possible, 12 said that hygiene had priority, 3 thought that it depended on the household situation and that it would be difficult to change habits, and 1 respondent though it inconvenient that washing would need to be postponed. The 16 households that did not want to change because they felt they already wore or used items long enough had approximately the same average (15.5) as the 20 respondents who were willing. These two groups seemed to represent the extremes in 'longer wearing days': that it was either not possible to use articles longer or that longer wearing could be extended in any case.

Assuming that the 20 households each shift one category up then group 1 has 37 households (38 percent), group 2 has 32 households (33 percent), group 3 has 15 households (15 percent), and group 4 has 13 percent of the households. The average wash frequency would then decrease by 21 cycles per year, which is 5 percent.

Airing

Although only by three respondents, airing was mentioned relatively often (see Table 4.18) as a measure to achieve longer wearing. 'Sometimes' as opposed to 'never' airing did not influence the wash frequency; the group that aired 'sometimes' washed eight cycles per year less compared with the group that never aired. In contrast, airing 'often' did influence the wash frequency. Households that said they aired often (n=27) washed on average 90 cycles fewer than households that never or sometimes aired (n=77). 'Airing often' probably reflects a completely different style of textile maintenance. Dividing the sample into two groups (never/sometimes or often) explained 4 percent of the variance (ANOVA n=104, $p = .03$), whereas dividing it into three groups gave no significant reduction ($p = .11$). Airing was correlated in particular to professional status (-.37): the higher the social status, the more airing. It was also related to the practice of 'leaving clothes for a couple of days and wearing them again' (.35). Airing was negatively correlated to dryer possession (-.16). The three households that mentioned airing as a measure to wear clothes longer, aired 'never' to 'sometimes', so a reduction potential of 3 x 90 cycles exists, although this is only 0.7 percent of the total number of cycles washed by all the sample households in a year.

More wool

The wearing of more wool is related to wearing practices, to standards, and to the image of wool, which will indirectly influence laundering practices.

More wool was unconditionally acceptable for 14 percent of the respondents. With conditions such as 'blends', 'machine washable', and 'not scratchy' the percentage of respondents that thought more wool was acceptable rose to 30 percent. There was no direct relation, however, between acceptance of more wool and laundering practices. The argument of less heating required because of the warm wearing properties of wool was not mentioned by the respondents.

No quantitative question was asked about the number of woollen articles that were used regularly. Therefore, no conclusions can be drawn about the influence on the energy indicators of using a lot of wool. There was no relation between acceptance and maintenance or wearing practices for woollen clothing, but there was a relation to wearing in general: a positively relation to the wearing of blazer and blouses by the partner. In general the number of wearing days was longer for households that found wool more acceptable. This especially applied to sports clothing, bedding, and bathroom towels. In addition, wool was considered more acceptable in terms of the higher the professional status of the partner and the age and education of the respondent. Negative opinions about the maintenance of wool were related to wearing practices (e.g. number of wearing days). Positive opinions about wearing properties were related to professional status.

It is remarkable that the acceptability of more wool was related to the professional status of the partner and her/his wearing behaviour (e.g. more blazers). One of the arguments related to wool's appearance. It is not surprising that with shorter wearing days and thus having to wash woollen articles regularly, wool does not stay as attractive looking as cotton. It is likely that households with a high standard regarding clean articles choose not to have many woollen articles. As a result, they would wash woollen articles as frequently as do households that favour wool and have more wool but wear it longer. It would be an uphill battle to convince households that feel compelled to wash frequently that woollen articles can be worn longer, as the notion is probably at odds with their normal way of doing things. However, information can be accompanied by the image that households with a higher professional status use or wear wool more often.

Polyester/cotton blends in bedding

Only 4 percent of the households thought that bedding with a blend of polyester/cotton was acceptable. More synthetics in bedding were not acceptable for a number of reasons; these were mostly related to use characteristics such as being scratchy, causing allergic reactions, sweating, and so on. Compared with a normal cotton load, a blended load could save 10 percent of the energy requirement for washing and drying. Less than a fifth (17 percent) of the weight of the laundry in 3- to 5-person households consists of bedding, so the reduction potential per household is around 2 percent.

More space to line dry

More space for line drying is not restricted to a small niche for line drying; a special room or space for laundering activities was considered desirable by 51 percent or was already in use by 30 percent of the respondents. The results showed that no decrease in the number of tumble dryers was to be expected with the use of a special room for laundering. Therefore the large space would only cost energy.

Fifty-one percent of the sample said that the average size of a room should be $11m^2$. This would cost extra indirect energy, on average 11*.51*.14 GJ/m^2.hh.y = 785 MJ/hh.y. This is an increase of 7 percent compared with the energy needed for the textile maintenance process. Heating of this space would also cost extra direct energy.

Gas-fired dryer

As well as having a high reduction potential, a gas-fired dryer can also have a counter effect: acquisition because of the low energy use by households that do not have a tumble dryer at the moment. It was concluded (section 4.9) that in the short term there was a potential of 7 percent of households opting for gas-fired dryers. Of these households, three had an electric tumble dryer that was 9 or more years old, and replacement by a gas-fired dryer would be an improvement. Four households, however, did not have a tumble dryer. The reduction potential therefore would be zero or slightly negative if a tumble dryer were introduced where one was not already present.

Selective use of the tumble dryer

Selective use of the tumble dryer can lead to either a lower frequency of use by more line drying or to lower loads by more selective loading, or both. Comments were given by 38 households: 12 would want to but already use the dryer selectively; eight could line dry more frequently inside and eight more often outside; four could use it more selectively for just the towels, sheets, or underwear and line dry the rest; and four thought it not possible because of lack of space. Frequent use of the night rate, no replacement if the old dryer broke down, and buying a more energy-efficient dryer were each mentioned by one household. When the comments were taken into account it was seen that only 35 percent (n=22) of the tumble dryer owners were really prepared to use the tumble dryer more selectively or more efficiently.

- Sixteen households mentioned more line drying (25 percent of the tumble dryer owners). These households tumble dried more often than average: 91 percent of the washed cycles and 63 percent of their entire amount of washed laundry. Assuming that the average frequency (91 percent) of these households would decrease to the average percent of the other households, this would save 5 percent of the energy needed for tumble drying. Assuming that their average tumble dry frequency would decrease to 50 percent, this would on average save (91 percent*25 percent*25 percent) 6 percent of the energy for tumble drying.
- Lower loads: the survey results indicated that the average tumble dryer load was approximately 2.3 kg and not 3.3 kg as seen in the literature. None of the households mentioned drying with higher loads as a reduction option, and only four households mentioned more selective loading. To establish the optimal load for specific loads such as sheets, jeans, towels, socks, and underwear, or for clothing of different types of material, a field survey investigating qualitative and quantitative tumble dryer use and laboratory tests could be useful.

More selective use was out of the question for 65 percent of tumble dryer owners. This included households that could not use the tumble dryer more selectively because they did not use their tumble dryer often or not at all. However, the relation between filling and willingness works the opposite: the more the tumble dryer was filled the less the households were willing to use the dryer more selectively, although this correlation was just significant (τ_c -.14, α= .05, n=61).

Significant correlations existed between selective dryer use and seven other variables: households willing to use the tumble dryer more selectively discarded clothing more often through collections by charities (τ_c = .25); they had a lower tumble dryer filling rate for fine or synthetic laundry (τ_c = -.24); they changed less often for different activities (τ_c= -.20); and clothing that did not look presentable enough was an important reason to launder an article (τ_c =.20). The three other variables were partner orientated: The more time the partner spent out of the house outside of working hours (τ_c =.25), the more articles the partner wore (τ_c =.29) but, unexpectedly, the fewer undershirts the male partner used (τ_c = -.24), the more willingness existed to use the tumble dryer more selectively.

No significant relations existed regarding any of the household variables like education and income. Correlations indicated that those households more willing to change their drying behaviour were ones that washed their clothing carefully and needed neat clothing, but were not necessarily careful in their wearing practices.

No dryer in the future

Sixty percent (n=62) of the sample households owned a tumble dryer. Of the remaining 40 percent (n=42), 81 percent (n=34) did not want a dryer in the future either, 14 percent (n=6) were thinking about it (doubts about shrinkage, high energy use, and not really necessary because of having enough time and space), and 5 percent (n=2) were sure that they wanted a dryer in the future as well. Two households that said they did not want a dryer in the future responded positively when asked whether they would like a dryer in a special laundry room. The percentage of tumble dryer owners among family households therefore could rise from 60 percent to somewhere between 62 percent (most cautious prognosis, based on only two households that were certain they wanted a dryer in the future) and 69 percent (based on ten households, of which six expressed doubts, two gave an inconsistent answer to two questions, and two that were sure they wanted a dryer in the future). This latter figure in expected future dryer ownership would lead to an increase in energy use of 8 percent for the total laundering process.

Summary of the domestic energy saving potential for textiles

Of the six proposed reduction options, only washing at lower temperatures gave a promising result (Table 4.18).

Selective loading of tumble dryers needs further investigation. On the basis of the above-mentioned calculations, the options washing at lower temperatures, longer wearing, and airing together would save 13-15 percent of the energy needed for washing (236-272 MJ/hh.y); the option line drying would save 108 MJ/hh.y of the energy needed for drying. These four options would save 9-10 percent of the direct energy needed for the laundering process, and 3-4 percent of the total energy needed.

Table 4.18 Summary of the domestic energy-saving potential for the activity category Textile Care

Option	Energy requirement (MJ/hh.y)	(%)	Technical saving potential (MJ/hh.y)	Survey Potential (MJ/hh.y)	(%)
Washing	1810	17			
Lower temperatures			344	127-163	7-9
Higher average load			290	5	.3
Longer wearing			-	91	5
More airing			-	18	1
Drying	2164	20			
More space for line drying			151	-	+7
More line drying			1969	108	5
Gas-fired dryers			1082	0	0
Penetration rate of dryers 50 percent→ 62-69 percent			-	+2683-2986	+19-28
Total*	3974	37		349-385*	9-10*[1]

+ Extra energy consumption instead of energy saving

** More space for line drying and higher dryer penetration not included, as they cost extra energy*

[1] savings percentage based on the total energy requirement

At present the most promising options seem to be:

- washing at lower temperatures, including 25°C cycles (7-9 percent of washing),
- longer wearing with its connected practices (5-6 percent of washing), and
- line drying (as part of selective drying, 5 percent of drying).

4.12 Discussion and conclusions

The results are briefly discussed in the last section of this chapter, and conclusions are drawn to answer the research questions mentioned in the first section. First the research questions are repeated and then implications of the results per question on an abstract level are described.

(1) *Wat does laundering consist of, what are the energy indicators and relevant behaviours, and what are the relations between, and the determinants of, the behaviours?*

The most relevant behaviour within the laundering process was the use of textiles in a broad sense and in particular the number of days that articles were used. The combination of demographic variables and textile use in a broad sense caused the variations in the amount and composition of the laundry. The combination of amount and composition, and the planning of laundering then determined which of the five sorting methods of the bulk was applied. This influenced the average wash temperature, the wash temperature of coloured laundry, sets of detergent use, and the number of laundry types that were distinguished (general sorting). The latter influenced average load weight (but not the load weights of the bulk of the laundry) and the average number of hand washes, and consequently wash frequency. The load weights of washing machines and tumble dryers were influenced by the extent of their users' environmental awareness, by their opinions about careful maintenance, and by general sorting. The combination of demographic variables, textile use, amount of laundry, and planning of laundering then influenced dryer possession, dryer use, and space use.

One could argue that a sorting method consists of several strategies for different kinds of laundry, firstly for the bulk and secondly for other items. From the findings it can be derived that the sorting strategy depends on the amount of laundry and on the relative types of textile articles. Consequently the composition of the wash loads will differ. It is likely that some methods will be used more often, or in specific combinations by certain households. The most energy-friendly way to launder is to sort the bulk into white and coloured loads.

In short, the type of determinants that influenced laundering were demographic determinants (e.g. social economic class), which influenced 'situational' determinants (e.g. stock, type and material of articles), and behavioural determinants, which influenced sequential behaviours. Further, religion, environmental awareness, and beliefs about attributes of appliances and careful maintenance all influenced choices, such as use of articles, wash temperatures, and loading of the tumble dryer. These determinants can be seen as household standards and skills or 'normative and operative' determinants. The reasons, conscious ideas, and salient beliefs that respondents gave for their behaviours ('motivational' determinants) did not always match the actual and measured variance in these behaviours.

The energy indicators were at first assumed to be (1) wash frequency, (2) weight of the load, (3) average wash temperature, (4) number of laundry types, (5) dryer possession, (6) loading and use of the dryer, and (7) textile use. In particular, weight of the load and number of laundry types were not such clear indicators.
In this research a different set of indicators was found: (1) amount of laundry or the wash frequency, (2) earlier changes in wash temperatures, (3) dryer possession, (4) selective dryer use, (5) textile use (bedding type and material, wool use, use days, leaving clothes for some days), (6) space use, and (7) planning of laundering. Called *laundering indicators*, they describe the relevant issues of laundering and can offer an additional way to address energy reduction options. The laundering indicators are more suitable to use in communication about energy saving for laundering because they are about practices rather than physical quantities, and therefore will be easier for households to comprehend and to respond to.

(2) *Which reduction options for Textile Care are suitable to investigate? Do households accept these options and what is the domestic energy saving potential? What are the determinants of acceptance?*

It was decided to select reduction options that met the following requirements: they were available, they were applicable in the present day situation, and they were related to direct and/or indirect energy and to the energy indicators: in short, washing, drying, and textile use, and finally to behavioural as well as technical changes. Two reduction options were chosen for washing: using lower temperatures and a smaller washing machine; two were chosen for drying: space for line drying and a gas-fired dryer; and two were chosen for textile materials: use of cotton/polyester in bedding and more use of wool. Theoretically these single options can save nearly 30 percent of the total energy needed for textile care.

In addition, five general questions (G:) on changes in laundering were asked, concerning washing in general, selective drying in general, wear and use time of articles, textile material use, and other possible changes. 'Derived' options such as load weight and airing, based on differences between households in the survey, were also calculated.

The theoretical energy-reduction potential for the activity category Textile Care is higher than the domestic energy-saving potential. Including the acceptance, the theoretical reduction potential, and the possible shift in practices, the most promising options seemed to be:

- washing at lower temperatures, including 25°C cycles (7-9 percent of washing),
- longer wearing with its connected practices (5-6 percent of washing), and
- line drying (as part of selective drying, 5 percent of drying).

The energy-saving potential of selective loading of tumble dryers needs further investigation.

The options 'washing at lower temperatures', 'airing', and 'longer wearing' together could save 12-15 percent of the energy needed for washing (218-272 MJ/hh.y), and the option 'line drying' could save 108 MJ/hh.y of the energy needed for drying. These four options could save 9-10 percent of the direct energy needed for textile care and 3-4 percent of the total energy needed for textile care. The expected rise in tumble dryer penetration would undo this domestic energy-saving potential.

Responses to the five general questions were a little less negative than those to the six single reduction options, and they varied between 49-83 percent negative. For the six single reduction options the 'no' answers varied between 43-96 percent; in addition, many responses contained a condition. Questions about the reduction options were answered distinctly but the willingness in general was distributed normally, which indicates that households' unique situations lead a different mix of choices. Nevertheless, 'washing differently', 'longer article use', 'wash coloured laundry cold', and the gas-fired dryer can probably be treated simultaneously, as well as selective dryer use and the use of more wool, along with 'blends' and 'other solutions'.

Determining variables of the answers to the reduction options were demographic ones, such as social economic status, religion, and household size (for wearing days and total amount of laundry); practices such as combining household tasks, using energy-saving light bulbs, and heating the dry space, as well as opinions, beliefs, wishes or attitudes related to dryers and dryer use.

The result of the factor analyses showed that eight factors should be taken into account when trying to achieve energy reduction in the activity category Textile Care: namely, (1) 'selective dryer use is possible', (2) the influence of social status on the use of articles, (3) the wish for special space for laundering, (4) flexibility in change, (5) uncomplicated wearing, washing, and drying, (6) the reasons for the amount of laundry, (7) heating of the dry space, and (8) whether 'other solutions' are possible.

Besides the flexibility in washing procedures, indications for 'flexibility' or openness to change were found on a different level as well. Reserving household time led to more combining of household tasks but to less acceptance and to fewer perceived family member influences on the laundering process. It is likely that this can be compared with a concept in social-psychology, such as 'proneness to change'. The results indicate that flexibility and the organisation of household tasks are probably a good direction in which to investigate relations with the acceptance of change.

(3) *Are behaviour and reactions to proposed reduction options (behavioural change) related? Do behaviour and behavioural change share variables?*

A third of the behaviours and reactions to reduction options were significantly related. Often, six out of eight of these relations were linear. The two others were 'parabolic': that is, a group with average behaviour responded differently to a reduction option than did groups with higher or lower scores on behaviour. Environmental awareness had a magnifying effect in only two relations. Changes in unusual situations were of less importance for general acceptance. The results showed that responses to the reduction options and to the practices were related. In order to save energy through behavioural change, both should be taken into account. The relations can be further investigated with more precise operationalisations.

Determinants that were related to behaviour and to willingness to change were compared. Variables that are shared by actual behaviour and willingness to change can be related negatively or positively to a behaviour that is environmentally friendly or unfriendly when it increases. In this way the interrelated variables can lead to new hypotheses about the consequences of changing behaviour, or to advice and measures to take into account when aiming to change behaviour in an energy-sound direction. By applying this 'interrelation' approach it was shown that all the combinations of behaviours and responses to reduction options shared a limited number of variables. Most relations appeared to be causal and a closer examination revealed that indeed they were. The 'interrelation' approach was applied on a specific level (e.g. dryer possession - wish for a gas-fired dryer) and on a wider level (e.g. dryer possession - wash coloured laundry at 25°C). On the wider level the shared determinants were only summed up and not interpreted. The question is whether the discovered relations and interrelations still exist when the variables become dynamic (e.g. through interventions). Whether the approach works and gives the right kind of 'determinants' and directions for advices and measures can only be determined by investigating interventions that take into account behaviour and willingness to change, as well as their determinants and the interrelated variables.

(4) *Can extra saving measures and advice be generated from this household perspective?*

New hypotheses (see §4.9) about the consequences of behavioural change were formulated not by applying the household perspective in itself but by focusing on the shared variables of behaviour and willingness to change. These were elements that the respondents were not consciously aware of: for example, about the relations between:

- The use of space and the use of wool in relation to amount of laundry and dryer possession;
- The use of stain pre-treaters, bedding, and planning in relation to wash temperatures and dryer use.

On the basis of these assumed causal relations, the measures and advice are relatively nuanced.

Reflection

One could say that in analysing the variables related to responses to reduction options, most of the work is done. However, more data comes to light when variables are analysed in a wider context. This can be done by comparing the three sets of determinants related to behaviour, to behaviour and behavioural change, and to behavioural change. In this way more demographical and situational variables and variables about planning, practices, and flexibility in earlier or other changes are found. This also explains why there is often a deviation between willingness to change and actual environmental friendliness of behaviour: Different sets of determinants prevail.

The respondents' reasons for behaviour and behavioural change were not reflected in actual behaviour or in the interrelated variables found using the interrelation approach. This indicates that an individual approach that focuses on salient beliefs is not sufficient to explain the space for change. In particular, flexibility in behaviour and the organisation of household tasks need to be investigated further; this is done in Chapter 5. These concepts are approached on the basis of a household science perspective and benefit from a social-psychological perspective for explanations.

5. Household Organisation and the Acceptance of Energy Reduction Options

5.1 Introduction, objective, and research questions

The behavioural activity of households strongly influences their energy consumption. However, the role of household activity organisation has not yet been investigated. In particular in family households many tasks need to be performed simultaneously and often with a lack of resources, such as time; in these instances different organisational solutions need to be found. Likewise, the acceptance of change to reduce energy consumption can be related to the organisation of household activities, especially when more energy reduction options are involved. It appears that when households undertake energy-saving measures, the feeling soon arises that one 'is doing enough for the environment' (van Meegeren and van Woerkum, 1994). Up to now, scant research has been done on what households need to implement a number of changes simultaneously. Most changes require effort or are subject to other considerations. Because of the possible relation of acceptance of change to the household organisation, it might be useful to address the considerations for change from the perspective of household organisation as well, certainly when the goal is to generate several changes.

The overall objective of this thesis was to investigate the influence of household management on the acceptance of reduction options and consequently on the energy-saving potential. Household management includes both the execution and the organisation of tasks (see Chapter 3). Chapter 4 focuses mainly on the functional level and on the acceptance of single energy reduction options. To examine whether simultaneous changes in households can be applied in order to change consumption patterns, this chapter focuses on a larger range of energy reduction options and on the organisational level. Three of the four research questions formulated in Chapter 1 are addressed:

(2) *a. How are practices and willingness to accept single energy reduction options related?*
b. What are the determinants of the practices and the willingness to accept single energy reduction options at a functional level?
c. What is the relation between practices and willingness to accept energy reduction options, when extended to an aggregated level?

(3) *a. How are characteristics of household management at an organisational level related to practices and to the willingness to accept energy reduction options?*
b. How many and which reduction options are accepted?
c. What are the determinants of the eventual accpeptance of change?

It was hoped that several energy reduction options could be applied in groups or in clusters. This would give information about how to combine reduction options and might help to find interventions that aim at helping households to accept several reduction options. This leads to the following research question:

(4) *Is it possible to form a typology of reduction option clusters? If any, which reduction options make up these clusters?*

To answer these questions, a general survey consisting of a quantitative questionnaire was held to determine a household's willingness to accept 31 different energy reduction options. A smaller follow-up survey then took place to check whether preferred reduction options in the general survey had actually been carried out. Concepts derived from literature studies on households and related to the organisation and considerations for change are described and operationalised in §5.2. A quantitative study was undertaken to estimate the energy-saving potential of a range of reduction options and the ones chosen. Extensive details are given in Chapter 2 and in appendices and are presented briefly again in §5.3. The survey structure and the sample representation are reported in §5.4. Single reduction option results for the relations between use and willingness to change are described in §5.5. Results of the different aggregated concepts that measure aspects of household organisation are described in §5.6. The reduction options and the use as questioned in the survey are also aggregated and analysed in §5.6. Willingness to change and the use are analysed in §5.6.3 using regression analyses in relation to certain demographic and household aspects. Factor analyses to find clusters of reduction options and the considerations for change are described in §5.7. Results of the follow-up survey are described in §5.8. Finally, the conclusions and discussions are given in §5.9.

5.2 Concepts in the literature regarding household management and willingness to change

In this section the literature as described in Chapter 3 is used to derive concepts that can be used to operationalise the research questions. This begins with concepts relating to the organisational and then the functional level; finally, considerations related to willingness to change are explored.

5.2.1 Concepts relating to the organisation of households

According to the Collins Dictionary, the organisation of a household encompasses 'the act of organising' or 'the state of being organised'. Organising is the forming or arranging methodically parts or elements of something into a structured whole (Collins, 1995). For households, this implies that people and gender roles, material and nonmaterial resources (including resource allocation), types of processes and activities, demands from the environment, and wishes or standards as well as goals are arranged such that a continuation of the whole, or an improvement of parts of the whole, is guaranteed. This includes methods of arranging all of these: for instance, through types of decision making and conferring.

For this thesis, a specification in the definition was made. Household organisation is seen as the 'state of being organised', several aspects of which can be measured, as opposed to the 'active act to arrange'. No investigation was done as to how active behaviour to organise takes place, as that aspect was not related to the research questions.
Before the discussion on ways to describe household organisation, a description follows regarding which activity categories can be distinguished.

Activity categories that can be distinguished are derived from and redefined by Walker and Woods, 1976; Aldershoff and Baak, 1986; Kirjavainen, 1989; Drooglever-Fortuin, 1993; Vijgen and Engelsdorp-Gastelaars, 1991; Antonides *et al.*, 1996 and Luijkx, 2001 (see also §3.4). Not only the functional activities are organised, such as consumption, production, and maintenance (i.e. committed time), which are frequently investigated in time studies. Resource acquisition (i.e. contracted time) is part of the overall household organisation as well, as are activities that take place in leisure time.

Table 5.1 Categories of household activities

Categories of household activities		
Food	House	Clothing and Shoes
Daily Purchases	Care and Guidance	Work and Study
Other Activities and Help	Leisure Time	Social contacts
Organising/Planning/Confer	Large Purchases (furniture, appliances)	

These categories encompass the following[20]:

- Food: making breakfast and lunch; cooking; making coffee and tea; eating/setting/clearing the table; dish washing;
- House: clearing and cleaning (vacuuming /dusting /windows /wc /doors /floors /bathroom /furniture /polishing copper and silver /making beds); animals, plants, garden; maintenance and repair of the house;
- Clothing: washing/drying/clearing; ironing; airing/beating; sewing/knitting/repairing; polish shoes;
- Daily Purchases: grocery shopping; take-away-meals; shopping for clothes and the house; counter services and other services outside the house (laundry, dry cleaner, shoe repair, hairdresser, medical care);
- Care and Guidance: taking care of children (dressing, bathing, changing, feeding, taking to bed, homework, medical care); spending time (playing, talking, cuddling, reading to, reprimanding, outside activities); other activities (talking to teacher, visiting school evenings and performances); guidance (to school, day care, dentist, friends, club, and so on.); care

[20] Households in the sample received a separate sheet on which the different activities and tasks in the activity categories were described.

and guidance of other members of the household except children (e.g. partner or grandmother);
- Work and Study: working/studying; therapy/revalidation/courses; transport to work, and so forth;
- Other Activities and Help: sport (or paying a visit to watch someone sport) or other clubs; activities for charity, church, schools, political or lobby organisations etc., help to/from family or households other than family;
- Leisure Time: rest/sit; having coffee/tea/a drink; watching TV/reading; listening to music; hobbies/games; going out (movie, dinner etc.); going for walk/day out;
- Social Contacts: visits; drop by; telephone; talk to people; writing letters/cards;
- Organising/Planning/Confer: organising and planning; conferring between household members, conferring with the one who needs/gives help; arranging services (plumber, tax forms);
- Large Purchases: finding information, comparing features, considering; purchase.

Using Chapter 3 as a basis, ways to describe the evaluation and organisation of household activities are discussed.
Several authors (see Chapter 3: Aristotle; von Schweizer, 1975; Egner, 1985; Drooglever-Fortuijn, 1993; Gershuny, 1983) define household organisation mainly in two dimensions, which are based only on the household activities. The first dimension concerns the balance between paid and unpaid work; related to this is who is responsible for which sorts of tasks (gender roles). The second dimension is related to what extent the household's activities are technically or economically interwoven with the household's environment. These dimensions are related to resources (income, time, access to resources outside the household) and to the way these are achieved. The household organisation can alternatively be conceptualized by:
(1) the household's situation, its resources, and the extent to which a household is interwoven with its social, cultural (including relations and opinions), and natural environments; however, in the literature the relation to social, cultural, and natural environments does not become apparent in the above descriptions of household activities;
(2) lifestyle entries, such as quality of life, standards and goals, opinions and feelings, types of processes and activities, and ways of organising these.

The following aspects are described in §3.4 and summarised in the following in order to extract concepts that can be used to investigate the organisation of households:
- The question of who feels responsible for the activities (possibly influenced by gender roles) (Pennartz and Niehof, 1999; Kirchler *et al.*, 2001) can be investigated by asking about the outcome, the *task division* between partners.
- Households can differ with regard to household production and resource allocation: more or less through the market (outsourcing); with or without technical solutions; with differences in efficiency, standards, and access to resources (von Schweizer, 1975; Egner, 1985; Groot-Marcus, 2004; Drooglever-Fortuijn, 1993). Household production and resource allocation encompass practices and organisational solutions that are often the result of creatively managing a shortage of time and money. Because of this origin and the

strong relation to one's identity and situation, these solutions are difficult to change. Even more organisational skills are needed to implement several reduction options, whereby some households can deal with more complex tasks better than others. Therefore it is important to investigate the ability to combine tasks (*Combining*), which is a measure of efficiency as well;

- Further, household production and resource allocation can be investigated by asking how much time is spent on work/travel/other obligations (contracted time), whether the household has *household help*, which appliances are used (*commodity use*), to what extent *home production* takes place, and whether standards for activities are high (*importance of tasks*). Drooglever-Fortuijn (1993) mentioned these strategies to solve time constraints in household production;
- A household consists of several members with different needs and expectations of the household management. An important aspect of shaping the organisation is decision making, which is preceded by discussing or conferring, especially when differences in goals, in opinions about goals or resource allocation, relative benefit, influence or power, or urgency and interest exist. Kirchler *et al.* (2001) consider it is of little use to develop a model of decision making that is organised along time lines (see §3.4), because of the incremental and relatively chaotic way in which partners discuss matters. Therefore it is thought that the *frequency of confer* is a relatively simple concept to reflect the interaction within households, which is related to decision making and to shaping the organisation;
- The perception of household activities gives an impression of the success of the organisation in terms of well-being (a lifestyle entry). Perception or significance of activities is related to the internal situation of the household: Who feels responsible for planning and executing the tasks; how the resources are allocated; meeting standards and specifications; time constraints; and the ability to combine tasks or to find alternatives, as well as the external situation of the household: demands of the surrounding community, society, and culture (Oakley, 1974; van der Vinne, 1998; see §3.4). It would take too long to investigate this in depth. However, it is assumed that the combination of experienced *pleasure* and *time constraints* gives an impression of how household activities are perceived.

It can be concluded from this theoretical exercise that lifestyle entries are more often used in the literature to describe households than is the relation to environments, but the above-mentioned concepts have not yet been used to describe household organisation in a more quantitative way. It is expected that the concepts are useful to measure and to describe the organisation of household activities, and they were applied in the general survey.

5.2.2 Considerations for change

Limitative, operational, and motivational aspects

Considerations for change may consist of limitative, normative, operational, and motivational aspects (Duijker and Vuyk, 1969).

Household consumption (Shove and Warde, 1997; Heiskanen and Pantzar, 1997) can be difficult to change, as patterns are embedded within social-cultural, technical, and structural systems. They also reinforce existing patterns through processes such as routinisation and use of commodities and services that are part of networks. Not only are many household activities deeply ingrained habits but they are also part of a series of activities. Determining aspects are mainly limitative, operational, and motivational, and thus important considerations for change are: effort, information, money, time, payback time, availability (limitative), knowledge, design features that influence use characteristics and compatibility with other activities, commodities or services (operational), image or brands, and the opinion of other household members (motivational).

With regard to reduction options related to indirect energy, households were asked whether more, equal, or less time, money, necessary knowledge, and effort would be needed to consider or apply an option. Questions were kept simple compared with those about direct energy reduction options, because little is known about what people think of indirect energy options. It was assumed that a first indication was sufficient. Questions relating to direct energy were more elaborate.

An overview is given In Table 5.2 as to how considerations were investigated for the different reduction options.

Table 5.2 Considerations for change and reduction options

Considerations: type of question:	Asked for the reduction options:
More/equal/less: * Time * Money * Effort * Knowledge	Natural materials vs. synthetic floor coverings Conserved vs. fresh vegetables in winter Meat replacements vs. beef or pork Other gifts vs. flowers
A reason to buy / neutral / reason to refrain: * Payback time (price/life/savings) * Amount of information needed * Time to process the information * Aspects in use (e.g. design) * Opinion of other household members * Better for the environment * Availability	Green electricity Water-saving shower head Energy-saving light bulbs Most energy-efficient appliances

The four direct energy options were investigated more often and thus the considerations were specified in order to generate new information.

Normative aspects

With regard to normative aspects, a number of considerations were taken into account. The standards for household management, even when environmental norms are incorporated, can differ from the more general opinions about environmentally friendly behaviour. The result of household behaviour can influence decisions to change or maintain change, also depending on whether the results meet household standards (functional compatibility [Groot-Marcus *et al.*, 2006]). Therefore it is important to investigate environmental awareness and whether environmental standards are incorporated into household behaviour in relation to the importance of the result of the behaviour and to the preferences for reduction options.

The scale used to determine environmental awareness was used in the National Monitor of Environmental Behaviour and was tested thoroughly (Couvret and Reuling, 1998). It consists of six questions; in this research it is related to the acceptance of reduction options and its relative importance is compared with aspects of household organisation.

As well as a scale for environmental awareness in general, a more specific scale was developed to measure whether the environment was taken into account in household behaviour. These questions related to fields of activities for which the reduction options also applied, such as carpeting, appliance use, holidays, heating, car use, food consumption, and other practices. The type of questions often used until now (e.g. do you separate glass bottles, etc.) as being indicative of environmentally sound household behaviour where considered too specific for this research. They were seen as ‘practices’ and were therefore addressed in the questions about specific energy reduction options.

Knowledge

Knowledge about reduction options and how to obtain and use them (limitative, operational) is important in willingness to accept as well as in actual application. Knowledge about the 31 options was examined at the end of the questionnaire (i.e. whether the respondents had been aware of the options before reading about them in the questionnaire [no/vaguely/yes]).

Spreading vs. clustering and mainstream vs. early market

Benefits can be a motivation for change. This change can be satisfying in terms of saving resources (time, money, effort), environmental benefits, better results, approval of others, enjoying activities more, or adding to experiences. The Mental Accounting theory (Antonides *et al.*, 1996; Kahneman and Tversky, 2000) predicts that when consumers enjoy the changes, these can best be spread over different activity categories. In that case more pleasure is experienced as compared with changes in one activity category. The reverse applies for changes that are not liked. Assuming that changes are accepted when they are liked, it can be hypothesised that changes occur diffusely over different activity categories.

It is expected that the ‘early market’ (Rogers, 1995; Moore, 2000, see Appendix 3.A), (i.e. the market of visionary adopters of innovations) is both more energy friendly in its behaviour and more willing to change the household activities, due to its visionary attitude. However, it is expected of the 'mainstream market'—due to its pragmatic attitude—that energy friendliness and willingness to change at the level of single reduction options are more specifically related to the household situation. This implies that the mainstream market’s energy friendliness and willingness to change are not necessarily related to each other on a more aggregated level. In this thesis, households are divided into an early (top group) and a mainstream market (mainstream group) by means of the scores on aggregated variables about willingness to change and the actual energy friendliness of household behaviour.

5.2.3 Concepts for willingness to change

Acceptance was mentioned in the research questions and was examined twice in the general survey (Willingness to Change and Attractiveness) and once in the follow-up survey (New Use).

General survey

To distinguish it from Acceptance, which was used in the case study, in the general survey the term Willingness to Change was used. At the most attitude or intention about change was measured.

Firstly, for each practice a household was asked whether it was willing to accept a change (e.g. replacing meat with cheese). The willingness to change to the reduction options was asked dichotomously (no/yes) or ordinally (no/maybe/yes) and for some options (size, amount, frequency) in ratio scales, with increasing energy reduction.

Secondly, at the end of the questionnaire respondents were asked to choose from a list of 31 four of the most preferred reduction options that the household intended to try. This is called the Attractiveness and can be seen as an intention to attempt. Willingness to Change is linked to the perceived attractiveness of the options.

Follow-up survey

In the follow-up survey a year later, respondents were asked which of the 31 options had been considered, tried, and successfully implemented (no/yes). This was to obtain more insight into the value of the answers about willingness to change and into the respondents' processes of weighing.

5.2.4 Concepts at the functional level

All kinds of activities (see §3.3) can take place at the functional level. Depending on what is done, the actual activity concerns the use, the operationalisation, the execution, the performance, the application or the possession of something, as well as the carrying out of a practice, a routine, or a habit. It is not about thoughts, feelings, opinions, goals, standard, norms, or values; ultimately it is the activity itself that determines the energy requirement.

Each reduction option in the questionnaire was preceded by questions about existing practices. In this way more information was gathered about household management at the functional level. Practices and activities relating to increasing energy reduction were inquired about using dichotomous, ordinal, or ratio scales. Differences in practices were related to willingness to change. The practice can influence the space for willingness to change. In addition, the use characteristics can be employed to estimate the energy-saving potential, which will depend not only on acceptance but also on the magnitude of change.

5.2.5 Summary

A more thorough description of the operationalisation of the concepts and the reduction options is given in the following section where the results are shown as well, which increases easy interpretation of the meaning of the results.

5.3 Reduction options

The 31 reduction options used for this survey included a mix of direct energy and indirect energy options (see Tables 2.2 and 5.4). The options are related to both changes in purchases and to household management practices, including larger investments and daily shopping. The categories were Food, House, Clothing and Textile Maintenance, Transport, Social Contacts (giving flowers), Leisure Time (holidays), and Large Purchases.

Table 5.3 Concepts and questions relating to household management and acceptance of energy reduction options

<u>Concepts related to the organisation of household activities</u>
Task Division (responsibility and gender roles)
Combining (efficiency, ability to execute and to organise complex tasks)
Frequency of Confer (interaction between household members/partners; decision making)
Importance of Tasks (relative standards)
Contracted Time (work/study/travel/obligations outdoor) vs. committed time (household)
Home Production vs. the use of services
Commodity (appliance) Use
Use of Household Help
Experienced Pleasure in household activities
Experienced Time Constraints in household activities

<u>Questions related to the functional level of household activities</u>
Way of executing (practices, possessions)

<u>Questions related to the willingness to change</u>
Acceptance per reduction option
Room for change (size, amount, frequency, in relation to the use)
Considerations for change (time, money, effort, skills, information, others, etc.)
Knowledge
General environmental awareness
Applied environmental awareness (personal norms applied to household activities)

The reduction options should save at least 0.5 GJ per household per year (see Appendices 2C and 2D for a description). In theory the combined reduction options save a little more than 25 percent of the yearly household energy requirement and are related to nearly 75 percent of the total household energy consumption.

5.4 Description of the sample

Data used for this chapter were collected in a general and a follow-up survey, both of which were quantitative and written.

Table 5.4 Activity categories and the formulated reduction options

Activity category	Direct energy	Indirect energy
Food	Pre-rinsing dishes; cold or no water Smaller fridge Smaller freezer No replacement of freezer	Conserved vegetables i.s.o. pre-frozen, imported or greenhouse vegetables Replace pork/beef (chicken/fish/vegetarian)
House	Water-saving shower head More energy-saving light bulbs Heating 1°C less (day, evening, night) Green electricity	Natural floor covering i.s.o. synthetic
Clothing	Wash 10°C lower (white, colour, dark) Use textiles longer before washing Change dryer use (less articles or loads) No replacement of the dryer	
Transport for the activity categories	Use the bicycle more often Use more public transport Get rid of the car Drive less	Lighter car Sharing a car through a company Sharing a car with another household
Social Contacts		Gifts, eco-flowers or plants vs. flowers
Leisure Time	Holidays closer to home	Holidays longer, further, fewer Holidays in a tent instead of apartement
Large Purchases	Most energy-efficient appliances Install a solar boiler	

General survey

The general survey was sent to respondents throughout the Netherlands and was held in February-April 1999. To find households, an advertisement was placed in local newspapers in the provinces of Utrecht, Gelderland, Noord-Holland, Westland (Zuid-Holland), West Brabant, and partly in the north of Zeeland. Households in the provinces Groningen and Drente were addressed using the snowball method. In total, one million households received a door-to-door newspaper carrying the advertisement, which asked for households (with children) that wanted to participate in research about environmentally sound household behaviour. A modest compensation was promised. Households that wanted to participate could send a postcard with their address, and approximately 400 households did so. In total, 376 households returned the questionnaire and received a gift voucher of 5 euros in July 1999. The households also received a summary of the results and further information about the reduction options. The summary and additional details were not intended as an intervention but it is possible that they served as a reminder.

Representativeness of the general survey

For Dutch families, the sample was representative in most aspects, such as income, age, house ownership, labour participation, work hours, partnership, number of children, average age when the first baby was born, urbanisation rate, and educational groups. The only distinguishing feature was that the female respondents in the higher professional education group were a little over-represented. They were also more often at home than the university-educated women in the sample.

Follow-up survey

Households received a short quantitative follow-up survey in April 2000, approximately a year after the general survey. The follow-up survey consisted of an overview of the 31 reduction options and briefly inquired which of the behavioural changes had taken place since the general survey and following receipt of the additional information in the summary. Three main questions were asked: whether the reduction options had been considered, whether they had been tried, and whether the households had succeeded in applying them. Households were invited to share and to write down their experiences. In total, 234 households participated, which was 62 percent of the households that had filled in the general survey. For each household, data from the follow-up survey were matched to those from the general survey. The purpose of the follow-up inquiry was to complete the logical line of surveys and to determine whether acceptance of the reduction options investigated in the previous survey was reflected in actual behavioural changes.

Representativeness of the follow-up sample

Households that did not return the follow-up survey differed in two demographic and two motivational variables:

- In non-response households the partner had on average a higher education level (ANOVA, means, F: 4.7, p:.03) and the number of hours for obligations other than work and commuting time was higher, both for the respondent (on average 5.1 vs. 3.7 hours/week, ANOVA, means, F: 4.6, p:.03) and the partner (on average 4.5 vs. 2.8 hours/week, ANOVA, means, F: 4.8, p:.03);
- Motivational variables were also different: non-response households intended to move more often within 3 years (ANOVA, means, F: 6.2, p:.01) and they liked the questionnaire less (ANOVA, means, F: 21.3, p:.00).

For other differences see Appendix 5E.

Structure of analyses

In the following, the data are first analysed at the functional level: namely, the willingness to accept single reduction options is related to carrying out the practices (§5.5). In §5.6, aspects of the household organisation are aggregated to composed variables and scales, with which further analyses are done to investigate what caused the variance in willingness to change and the energy friendliness of actual behaviour on a more general level. In §5.7, the clustering of reduction options is investigated as well as what the considerations are for choosing options and what causes clustering or non-clustering. The follow-up survey is analysed in §5.8 and the statistical methods of analyses are described in Appendix 4A.

5.5 Results at the functional level

Results at the functional level are described in this section. The use behaviour is described and analysed in detail for two reasons: (1) no information is available about much of the household behaviour and (2) in this way the energy-saving potential can be determined. Further, the use behaviour is described in relation to the willingness to change. This was done with correlation analyses (Kendall's tau, Pearson's R). It is interesting to see the relation between use and willingness to change for so many different behaviours.

5.5.1 Activity category Food

Pre-rinsing dishes

Pre-rinsing was investigated in terms of how dishes were pre-rinsed: with warm running water, with warm water in a sink, with cold running water, with cold water in a sink, or not/seldom. This is an ordinal 5-point scale with increasing energy friendliness. Also investigated was whether the household possessed a dishwasher (dichotomous). This use behaviour is related to the reduction option, which consisted of the question 'for the good of the environment, how often can the dishes be pre-rinsed with cold water (running or in a sink): not applicable, a quarter, half or more than half' (increasing ordinal 4-point scale). This question implies willingness because of the reference to the environment.

Table 5.5 shows the relation between the reduction option practice and the willingness to change.

Table 5.5 Type of pre-rinsing and willingness to change to rinsing with cold water (%, n=371)

Type of rinsing	Willingness to partly pre-rinse with cold water				
	Not applicable	¼ of the rinses	½ of the rinses	> ½ of the rinses	Total
Warm running	1	14	8	4	27
Warm sink	2	6	1	0	9
Cold running	6	0.5	0.5	1	8
Cold sink	3	0	0	0	3
Not/seldom	50	2	0	1	53
Total	62	22.5	9.5	6	100

More than half of the households (53 percent) never or seldom pre-rinsed dishes. Households that pre-rinsed with warm running water were significantly more often willing to pre-rinse a larger part with cold water (in particular half or more than half of the rinses) than did households that pre-rinsed with warm water in a sink (ANOVA, Scheffé, F: 93.4, p:.000, n=370).

Households without a dishwasher (54.5 percent) rinsed in a less energy friendly manner than households with a dishwasher (τ_c:.24; p:.000, n=371). In particular, households that did not pre-rinse had a dishwasher more often than did households that rinsed with warm running water (ANOVA, Scheffé, F: 9.7, p:.000, n=370).

Table 5.6 Having a dishwasher and type of pre-rinsing of dishes (%, n=371)

	Type of pre-rinsing of dishes					
	Warm running	Warm sink	Cold running	Cold sink	Not/seldom	Total
No dishwasher	21	6	4	1.5	22	54.5
Dishwasher	6	3	4	1.5	31	45.5
Total	27	9	8	3	53	100

Households without a dishwasher were more often willing to do one-quarter or one-half of the rinsing with cold water than were households with a dishwasher (ANOVA, Scheffé, F: 10.6, p:.000, n=370; τ_c:-.18; p:.000, n=368), marked in the following table with *.

Table 5.7 Having a dishwasher and willingness to shift to rinsing with cold water (%, n=368)

	Willingness to partly pre-rinse with cold water				
	Not applicable	¼ of the rinses	½ of the rinses	> ½ of the rinses	Total
No dishwasher	28	16.5*	7*	3	54.5
Dishwasher	34*	6	2.5	3	45.5
Total	62	22.5	9.5	6	100

** Households without a dishwasher were more prepared to change one-quarter or one-half of the warm rinses than were households with a dishwasher and for whom change was not applicable.*

When only those households were taken into account that pre-rinse warm and were willing to shift to cold water it appeared that households with or without a dishwasher did not differ in their preferences for the number of cold pre-rinses (p>.15; n=125). Only for households without a dishwasher was it found that those not willing to change already pre-rinsed in a more energy friendly manner (ANOVA, Scheffé, F: 82.4, p:.000, n=167).

This means that households are more willing to shift to cold water when they pre-rinse in a less energy friendly manner. This in particular was valid for households without dishwashers. In general, pre-rinsing in households with dishwashers was more energy friendly.

Meat

Meat consumption was investigated in terms of how many times per week/month/year beef or pork, poultry, fish or other protein sources, such as cheese, eggs, legumes, and nuts, were eaten with the hot meal. This was recoded into the frequency per month.

Regarding the reduction option, households were asked how often they were willing to eat cheese, eggs, legumes, chicken, fish, bacon, vegetarian products (burgers, etc.) or tahu/tofu/tempe extra (per week or per month) instead of beef or pork. This was recoded into the frequency per month (weeks x 4).

Table 5.8 Average consumption of protein sources with the hot meal/dinner (frequency per month; n=376)

Beef or pork	Chicken	Fish	Other protein sources	No protein sources
15.7	5.1	3.0	4.1	2

This added up to nearly 30 days. On average, on two days per month no protein sources were eaten. The 38 households that sometimes did not eat a protein source did this on average 5.8 times/month. Five percent of the households were vegetarian and were not included in the following analyses.

Table 5.9 Possible replacements for beef or pork (frequency per month; n=357)

Cheese	Chicken	Eggs	Fish	Legumes	Vega product	Bacon	Tofu/tahu/tempe
5.1	5.1	3.9	3.8	2.6	1.7	1.4	1.1

This adds up to a substitution of almost 25 times a month for beef or pork, which was eaten 15.7 times per month. Possibly the reduction-option question was understood as the maximum frequency per type of protein source per week or month, not necessarily relating it to the existing consumption frequency of beef or pork. Because it is likely that the question was misunderstood, the relation between use and the response to the reduction option could only be analysed per protein type and not on a more aggregated level. In the following, the frequencies of consumption and of possible replacements are related:

- When more beef or pork was eaten, the number of times that tahu and so on could be used as replacement was lower (τ_c:-.13; p:.000; n=334). This was also valid for other vegetarian products (τ_c :-.16; p:.000; n=336). Bacon on the contrary was found more acceptable (τ_c:.13; p:.000; n=330);
- The more often chicken and other poultry were eaten, the preferences for fish and chicken as replacements for beef or pork were higher (τ_c respectively .13 en .31; p:.000; n=338);
- This was even more specific for fish: the willingness to replace beef or pork with fish was higher when fish was eaten more often in any case(τ_c:.29; p:.000; n=331);
- The more often a vegetarian product was eaten, the less often chicken (τ_c -.15) and the more often tahu and other vegetarian products were indicated as a possible replacement for beef or pork (τ_c respectively .20; .27; p:.000; n=314);
- There was no relation between the number of days that no protein sources were eaten and preferences for any of the replacements for beef or pork (n=38).

Apparently preferences were 'more of the same' for products that somehow share similar attributes: bacon is pork, and chicken and fish are easier to digest than red meats. This means that the use of types of meat and a possible shift to less energy intensive protein sources were quite specifically related. Habits (e.g. effort, time), familiarity (knowledge), or personal preferences for attributes (e.g. money, taste) might also have played a role.

Use of fridge freezers, deep freezers, and pre-frozen vegetables

Households were asked about type of freezer, fill rate, and for what types of articles the freezer was used. Types of articles were distinguished as pre-frozen and articles frozen after purchase. In particular it was asked how often pre-frozen vegetables were consumed per year. Freezer use was related to two reduction options: whether the household could buy a smaller freezer or not replace the freezer when the old one needs replacement (no/yes). The third reduction option was whether pre-frozen vegetables could be replaced by vegetables in tins or glass, which requires less energy to produce (no/yes), how often this would be possible per year, and which vegetables (maximum of three) would be canned or preserved.

There were 456 freezers of all sizes in the sample. The number of households in the sample was n=376, which meant that the penetration rate of freezers was 121 percent. For each type of freezer, figures about the volumes in litres were acquired from shops and manufacturers and an estimated average was calculated (Table 5.10). Table 5.10 also shows the penetration rate of each type of freezer in the sample.

Table 5.10 Penetration rate and estimated freeze capacity** (litres) per type of freezer*[21]

Type of freezer	(%)	Litres	Type of freezer	(%)	Litres
Small freeze compartment in table model refrigerator	16	17	Small chest	10	130
			Large chest	6	250
Combi, top freeze compartment	12	50	Freezer bar model	2	50
Combi, bottom freeze drawers	32	65	Table model freezers	22	100
Combi, parts equal size	8	90	Freeze cupboard	13	230

** penetration rate is the percentage of each type of freezer in this sample (n=376); this adds up to 121 percent*
*** estimated freeze capacity per type of freezer, figures acquired from manufacturers and shops*

A small number of the households owned more than one freezer: 72 households owned two and six households owned three. Of these 78 households, two groups that covered 73 of the 78 could be distinguished:

- Households with a table model refrigerator with a small freeze compartment had in particular a second (n=31) or third freezer (n=5). They had mainly table models, a combi, or a cupboard model as a second freezer. The combis provided extra cool capacity as well;
- Other households that relatively often had a second freezer were those with a combi with drawers at the bottom (n=21) and those with a combi with a top freeze compartment (n=16). They had mainly a table-, a cupboard-, or a chest model as extra freezer (no extra cool capacity).

Nine households had no freeze capacity (2.4 percent). In addition, 24 households (6.4 percent) had only a table model refrigerator with a freeze compartment.

Freeze capacity per household was calculated by adding the estimated average freeze capacity per type of freezer (including the freeze compartment of table model refrigerators). On average this was 117 litres (s.d. 88 litres), with a maximum of 580 and a modus of 65 litres (in 32 percent of the households).

Households with freezers (98 percent) said that their freezer was nearly empty (2 percent), one-quarter full (2 percent), half full (8.2 percent), three-quarters full (49 percent), or nearly or completely full (38.8 percent).

Compared with these average fill rates, freeze compartments in households' refrigerators were more often nearly empty (13 percent), one-quarter full (4.3 percent), half-full (8.7 percent), three-quarters full (39.1 percent), and almost or completely full (21.7 percent). Of the households with one freezer, those with only a freeze compartment in a refrigerator had a significantly lower fill rate than those with a combi with bottom drawers or one with equally sized compartments, table model freezers, and cupboard models (ANOVA, Scheffé, F: 4.4,

[21] A chest has a lid that opens, the others have a door; a table model is of table height, a cupboard is higher; a combi is a combination of a two-door fridge/freezer

p:.000, n=268). It is expected that freeze compartments in refrigerators of households with a second or third freezer are not used at all.

The used capacity was calculated by multiplying the total capacity in litres per household with the values 0.10, 0.25, 0.5, 0.75 and 0.9, when the fill rate was indicated as 'nearly empty', a quarter, half, three-quarter or 'nearly or completely full'. It was assumed that the fill rate was equal for different freezer types when households had more than one freezer. The result was that on average 92 of the 117 litres were used (79 percent).

Freezers were used for the following products:

- Most popular were ice-cream and frozen desserts (bought by 84 percent of the households), potato products (75 percent), meat and poultry (66 percent), frozen vegetables (65 percent), meat snacks (60 percent), dough (58 percent) and ready-to-eat meals (56 percent). Three percent of the households never bought frozen products;
- Households mainly froze bread (by 86 percent of the households), fresh meat (65 percent), followed by pre-cooked meals and leftovers (56 percent) and vegetables (49 percent);
- On average 8.9 types of products were stored in the freezer;
- Ten percent of the households never used pre-frozen vegetables or used the freezer for that purpose, 25 percent had pre-frozen vegetables but did not use the freezer to store them; 65 percent bought and stored pre-frozen vegetables in the freezer.

Households that had fuller freezers in litres had a higher freeze capacity in litres and a higher number of freezers, and used more types of frozen products (P's R respectively: .32; .29; .32; p:.000).

Acceptance of the reduction options varies between them, as is shown in Table 5.11.

Table 5.11 Willingness to change to three 'cool' reduction options (%)

Willingness	Replace frozen vegetables	Smaller freezer	No replacement of the freezer
In the sample (n=376)	52.6	n.a.	n.a.
With capacity = 17 litres (n=24)	31.8	n.a.	9.1
With capacity > 20 litres (n= 324)*	53.5	12.7	4.3

For willingness to try and application of these three reduction options the following relations were found:

- Willingness to change to the three reduction options was not significantly related to the fill rate, the used capacity, and the number of fridge- and deep freezers.
- Smaller freezers: households willing to change to a smaller freezer had a higher capacity (150 litres) (τ_c:.16; p:.000) compared with households that were not willing and had a freezer larger than 20 litres (124 litres, ANOVA/means, F: 4.1, p<.05), n=324).
- Frozen vegetables were purchased on an average of 39 times per year, and could be replaced 22 times (56 percent) (n=376);

- Pre-frozen vegetables (see Table 5.12): households with a higher consumption of pre-frozen vegetables used the freezer more often to store them (τ_c:.46; p:.000, n=364), were more willing to change to conserved vegetables (τ_c:.27; p:.000, n=349), and indicated a higher frequency of change (τ_c:.21; p:.000, n=339). However, the percentage that could be replaced was lower when consumption was higher; households that bought frozen vegetables fewer than ten times per year were 100 percent willing to replace, whereas 48 percent of the households that bought them more than 26 times per year were willing to replace (ANOVA, Scheffé, F: 3.9, p:.009, n=306).
- Households willing to switch to conserved vegetables stored more types of products (on average 9.5 types of products) in the freezer than did households that were not willing (8.5 types) (ANOVA, means, F: 8.9; p:.003, n=342).
- Households not willing to replace pre-frozen vegetables and who also did not store them had a significantly lower consumption of pre-frozen vegetables per year (19.6) compared with households that were not willing and who stored frozen vegetables in the freezer (44.7 times per year) (ANOVA, F: 20.7, p:.000, n=176);
- A similar difference existed for households willing to replace: Households that did not store the frozen vegetables had a frequency of 30.9 times per year, whereas households that stored frozen vegetables in the freezer had a consumption frequency of 49.6 times per year (ANOVA, F: 8.5, p:.004, n=169);
- Households that used the freezer to store pre-frozen vegetables and who were willing to change did not have a significantly higher frequency of possible replacement (41.8 times per year) compared with households that did not store pre-frozen vegetables in the freezer and that were willing to replace (29.7 times per year) (ANOVA, F: 2.4, p: .12, n=167).

Table 5.12 Storage of pre-frozen vegetables in a freezer and willingness to change to conserved vegetables in glass or tins (%, n=376)

Pre-frozen vegetables	Replacement not acceptable (%) and frequencies per year of consumption		Replacement possible (%) and frequencies per year of consumption and possible replacement			Total
	(%)	Frequency of consumption	(%)	Consumption	Replacement	
Not stored in freezer	21	19.6	14	30.9	29.7	35
Stored in freezer	26	44.7	39	49.6	41.8	65
Total	47		53			100

Consumption frequencies between the rows did not significantly differ, nor did the replacement frequencies for households that stored or did not store frozen vegetables and those that were willing to do so (rightmost column).

Responses regarding which pre-frozen vegetables could be replaced by conserved vegetables in tins or glass are shown in Table 5.13. This question was answered by 49 percent of the respondents.

Table 5.13 Vegetables that can be consumed conserved instead of pre-frozen (% of the mentioned vegetables (freq.=374) by n=184 households)

Vegetable type	1	2	3	4	5	6
Bought frozen	Spinach	Green beans	Peas	Red cabbage	Other legumes*	Kale
(freq.=374)	24%	18%	17%	14%	7%	5%

**vegetables mentioned were: broad beans, corn, legumes, brown beans, marrowfat peas, brown peas, haricot beans*

The conclusion was that households that bought frozen vegetables more often and stored them in a freezer were more willing to change to conserved vegetables. For the deep freezer, a relation only exists between a higher capacity in litres and more willingness to change to a smaller freezer. Few households were prepared to get rid of the freezer.

Freeze capacity is clearly a necessity for households. However, less use of pre-frozen vegetables and less freezer capacity is possible if households use pre-frozen vegetables frequently and have more freeze capacity. Perhaps the willingness can be explained in terms of demographic characteristics: for instance, a high ratio 'freeze capacity/number of household members'.

Refrigerators

Households were given a list of different types of refrigerators and asked which ones they owned. The reduction option investigated was whether the household was willing to buy a smaller fridge when the old one needed to be replaced (no/yes). As with freeze capacity, the fridge capacity per type of fridge was an estimated average based on figures provided by manufacturers and shops.

Table 5.14 Penetration rate (%, n=368) and estimated average cool capacity per fridge type (litres)

Fridge type	(%)	Litres*	Fridge type	(%)	Litres*
Table models			Combination fridge/freezers		
- without freeze compartment	23	150	- Top freeze compartment	12	175
- with freeze compartment	16	115	- Bottom freeze drawers	32	200
			- Equal parts	8	220
Bar model	1	50	Cupboard model	20	270

** not measured in the sample but estimated average acquired from shops and manufacturers*

The penetration rate of refrigerators was 112 percent, lower than that for freezers. The average cool capacity was 212 litres (± 94 litre).

Five percent of the households did not answer the question as to whether they were willing to buy a smaller fridge. Eight percent were prepared to buy a smaller fridge, which is a relatively low percentage. No relation existed between willingness and cool capacity (ANOVA) or the type of refrigerator.

Because many appliances combine a cool and a freeze compartment, and because a higher cool capacity in litres was related to a higher number of freezers (Pearson's R:.27; p=.000; n=371), the relation of willingness to change to a smaller fridge with freeze capacity, type, and use (number of types of articles, fill rate, used capacity) was analysed as well. Households unwilling to change to a smaller fridge had a fuller freezer (ANOVA, F: 4.6, p<.05, n=341) and stored more types of products in it (on average 9.1, ANOVA, F: 4.2, p<.05, n=342) than did households that were willing (on average 7.8 product types).

Thus, households willing to change to a smaller fridge used the freezer less intensively, although there was no relation to capacity or number of freezers. This might also indicate how intensively the cool capacity was used.

Positive relations existed between more willingness to change to a smaller fridge and to three other reduction options related to conserving food:

- More willingness to change to a smaller freezer (τ_c.13; p<.000);
- A higher frequency with which households were willing to replace pre-frozen vegetables (Pearson's R: .14; p<.02, n=334);
- A higher frequency of replacement of imported or greenhouse vegetables (R:.23; p=.000, n=358) with conserved vegetables in tins or glass.

These results were an indication for clusters of options and showed that the willingness to change to a smaller fridge could perhaps be explained by something other than actual use (in this case, cool capacity and type of refrigerator). The relation to freezer use implied that the more intensive the use of the fridge the less willing households were to switch to a smaller one. In addition to the relation of willingness to change to a smaller fridge to the willingness to apply other food conserving reduction options, there was also a positive relation between cool capacity and number of freezers. This raised the question as to whether changing to lower cool capacities also influenced the number of freezers, the freeze capacity, and the consumption of pre-frozen, imported or greenhouse vegetables, and conserved vegetables. The intensity of fridge use could explain, at least in part, the willingness to switch to a smaller fridge, which might be partly related to the relative cool capacity per household member.

Fresh vegetables in winter: imported or greenhouse vegetables

Households were asked how often per week they ate fresh vegetables during the winter. The reduction option involved how often they were willing to replace imported or greenhouse vegetables, which require considerably energy to produce, with vegetables in tins (no/yes) or glass (no/yes). Three types of fresh vegetables could be mentioned and respondents could answer that they did not know for sure what vegetables were imported or grown in greenhouses.

Four percent of the households consumed fresh vegetables 0 or 1 time per week, 31 percent did so 2 or 3 times, 47 percent did so 4 to 5 times, and 18 percent did so 6 or 7 times per week. On average this amounted to 4.2 times per week (n=376).

For 40 percent of the households, replacement was not possible; for 27 percent it was. The remaining 33 percent indicated they were not sure which vegetables were imported or grown in greenhouses in winter. Of this group, 9 percent mentioned a number of times that they were willing to switch to conserved vegetables. In total, 136 (27+9=36 percent) households indicated how often they could replace fresh vegetables, and on average they were willing to do so 1.2 times per week. This group and the group that was not willing to change (64 percent) did not differ in the number of times per week they ate fresh vegetables (ANOVA, means, $p>.10$; n=368). Within the group of 136 households a negative significant relation existed between the frequency of use and the number of times that they were willing to change (Pearson's R: -.20; p: .02, n=135).
Answers to the question about which imported or greenhouse vegetables could be replaced by conserved vegetables in tins or glass are given in Table 5.15. For this question, the subgroup was selected that knew exactly which vegetables were imported or greenhouse (27 percent) and that was willing to change.

Table 5.15 Vegetables that can be consumed in conserved form (tins or glass) instead of greenhouse grown or imported in winter (% of the mentioned vegetables (freq.=194) by n=101 households)

Vegetable type	1	2	3	4	5
Greenhouse or import	Green beans	Carrots	Red cabbage	Beetroot	Spinach
(freq. = 194)	34%	14%	8%	7%	7%

Households answered correctly regarding more than half of the vegetables mentioned (green beans, smaller carrot types, and spinach) because these are spring or summer vegetables and need to be imported in the winter. Answers regarding winter carrots, red cabbage, and beetroot were not correct. These vegetables can be stored and consumed relatively fresh in winter and are not grown in greenhouses or imported (see Appendix 5F). Although the households indicated no uncertainties, they only partly knew which vegetables were greenhouse or imported in the winter[22]. Red cabbage and beetroot in particular do not have to be replaced, but as conserved vegetables these are commonly used and widely available. It is likely that the question was answered with conserved vegetables in mind and not with fresh vegetables as intended.

[22] Households that indicated they were not sure what imported and greenhouse vegetables were answered the question about which fresh vegetables in winter could be replaced by conserved vegetables. The question was answered by only 19 percent (n=24) of these households. They mentioned mainly green beans, carrots, and spinach (respectively 36 percent, 11 percent, and 11 percent of the mentioned frequency n=47) and knew what greenhouse and imported vegetables were just as well as the group that had no uncertainties.

It can be concluded that a little more than one-third (36 percent) of the households were prepared to shift from fresh vegetables 4.2 to 3 times per week to conserved vegetables. In general it can be concluded that no relation existed between the frequency of use of fresh vegetables in the winter and the willingness to change this. It is obvious that for many households it was not clear what greenhouse, imported, or seasonal vegetables were, even for the households that thought they knew.

5.5.2 Activity category House

For the category House, use behaviour was less thoroughly investigated than for Food. In the following, first the reduction options 'energy-saving light bulbs', 'water-saving shower heads', and 'green electricity' are described, followed by 'heating behaviour', 'gas and electricity consumption', and the 'floor materials' that were used and preferred.

Energy-saving light bulbs, water-saving shower heads, and green electricity

Households were asked how many energy-saving light bulbs were already in use and whether more would be purchased in the future (no/maybe/yes). They were also asked whether they made use of water-saving shower heads and green electricity (no/yes) and whether this would possible in the future (no/maybe in the future/yes).

Households could have combinations of selected and applied reduction options, which are shown in Table 5.16.

Table 5.16 Combinations of already applied options regarding energy-saving light bulbs, water-saving shower heads, and green electricity (%, n=376)

Number of options in use	Energy-saving light bulbs	Water-saving shower head	Green electricity	Percentage of households
3	*	*	*	3.5
2	*	*	-	39
2	*	-	*	1.3
2	-	*	*	0.7
1	*	-	-	28
1	-	*	-	13
1	-	-	*	0.5
None	-	-	-	14
Total				100

Only 3.5 percent of the households implemented all three options and 14 percent applied none at all. Nearly 72 percent of the households used energy-saving light bulbs. Households using only green electricity were rare (0.5 percent).

In Table 5.17 the possession or use is broken down by the answers to willingness to increase this.

Table 5.17 Possession of or willingness to use energy-saving light bulbs, water-saving shower heads, and green electricity (%, n=373)

Energy-saving light bulbs		Water-saving shower heads		Green electricity	
Possessed by	72%	Possessed by	56%	Used by	6%
- More in future	45%			- Will use in future	9%
- Maybe in future	45%	- Maybe in future	34%	- Maybe in future	64%
- No intention	10%	- No intention	10%	- No intention	21%
Total	100%		100%		100%

The use of energy-saving light bulbs, water-saving shower heads, or green electricity was not significantly related to the willingness to change to the other two reduction options; thus the possession of energy-saving light bulbs was not related to, for example, the willingness to change to green electricity and so on.

The relation between use and acceptance was only analysed for energy-saving light bulbs for two reasons: Firstly, the use could be distinguished in more than dichotomous answers (unlike water-saving shower heads and green electricity), and secondly, more than one shower head or contract for green electricity is usually not needed, but households with only a few energy-saving light bulbs might be able to use more. This made it possible to investigate the relation between use and willingness with regard to energy-saving light bulbs but not to water-saving shower heads and green electricity.

On average, households in the sample possessed 3.3 energy-saving light bulbs. The frequency of light bulbs was recoded to no possession/possession. Households that possessed energy-saving light bulbs were more willing to buy more in future as compared with households that had no energy-saving light bulbs (τ_c:.23; p:.000; n=373).

The 72 percent of households that possessed one or more had, on average, 4.6 energy-saving light bulbs. For them it did not count that when they had more bulbs they were willing to purchase more in the future (τ_c:.02; p>.50; n=268). This meant that there was no relation between the number of light bulbs that were owned and the willingness to buy more in the future.

It can be concluded that households without energy-saving light bulbs were less often willing to buy energy-saving light bulbs than those that already used them.

Electricity and gas consumption; heating

With regard to direct energy consumption, households were asked how much electricity and gas per year was consumed. Heating was investigated in terms of how high households usually set the thermostat in daytime when nobody is home, when somebody is home, and in the evening and at night. The reduction option investigated was whether 'heating one degree less' was possible during these periods.

About 70 percent of the households answered the question about energy consumption. Results are given in Table 5.18.

Table 5.18 Average yearly electricity and gas consumption

	Electricity use (kWh/year) (n=257)	Gas use (m^3/year) (n=261)
Per household	3431 (s.d. ± 1412)	1832 (s.d. ± 768)
Per household member	925 (s.d. ± 383)	501 (s.d. ± 236)

Electricity use and gas consumption per household were positively related (Pearson's R: .26; p:.000); electricity use and gas consumption per household member were related as well (Pearson's R: .27; p:.000, n=250).

There were significant correlations between the use of gas and electricity and of energy-saving light bulbs and water-saving shower heads. Households that used green electricity used less electricity (on average 2488 kWh/year) than those that used normal electricity (on average 3480 kWh/year) (ANOVA, Scheffé, F:4.2; p:.016, n=254).

Most households gave valid answers to the question about heating temperatures (see Table 5.19.

Table 5.19 Average heating temperatures and willingness to heat 1°C less

Part of the day	Heating temperature	Willing to heat 1°C less			Total
		Not	Maybe	Yes	
	(°C)	(%)	(%)	(%)	(%)
Daytime, nobody home (n=360)	14.8	40	39	21	100
Daytime, someone home (=359)	18.9	63	29	8	100
In the evening (n=359)	19.8	64	29	7	100
At night (n=348)	14.4	50	34	16	100

When the daytime temperature was higher it was also higher in the evening and at night. The highest significant correlations were between the daytime temperature when nobody is home

and at night (R: .69; p:.000), and between the daytime temperature when someone is home and the temperature in the evening (R: .57; p:.000).
The heating temperatures in the daytime when nobody is home and at night were positively related to gas consumption (respectively R: .24; p:.000 and 18; p<.01), despite the rough estimates made by some households. Willingness to change was not related to gas consumption.

Two significant relations were found between higher temperatures and more willingness to heat less at a specific time: for daytime when nobody is home (τ_c:.21; p:.000) and for daytime when someone is home (τ_c:.18; p:.000);

- Households that heated less in daytime when nobody is home (13.6°C) and when someone is home (18.7°C) were not willing to heat 1°C less in daytime. These temperatures were significantly lower than those of households that were or might be willing (ANOVA, Scheffé, daytime/nobody home: F: 19.3, p:.000; n=357; daytime/someone home: F: 6.3, p<.005, n=357). For the willing households, these temperatures were respectively 15.8°C and 19.8°C; for households that might be willing, they were respectively 15.8°C and 19.1°C;
- For evening hours, there were no significant differences in heating temperatures for willing and unwilling households;
- For night-time, the average temperatures differed significantly for households that were not willing (13.4°C) or might be willing to heat 1°C lower (15.7°C) (ANOVA, Scheffé, F: 10.7, p:.000; n=344).

Households willing to change to 1°C lower heating had 1 (in daytime when someone is home and at night) to 2 degrees (in daytime when nobody is home) higher temperatures compared with the unwilling households. Apparently in the heating behaviour there was room for a change to heat less in daytime and at night. As well as this room for change, the heating temperatures in daytime when nobody is home and at night were related to gas consumption, which makes this an interesting aspect to investigate further. For heating in the evening, reasons other than higher temperatures must exist as to why some households could heat less and others could not.

Floor materials

Households were asked what type of flooring material was mainly used in the living room, what types of natural materials (wool, stone, linoleum, wood, cork) they found attractive (no/yes) and whether they intended to buy one of these natural materials in the future (no/maybe/yes).

As can be seen in Table 5.20, 81 percent of the households already had natural materials in their living room. Despite the double counts, the differences between the percentages in attractiveness and use show a potential of 1.5 to 5 times of the used percentage in natural materials. Most households indicated that they would buy natural materials the next time (73 percent), 24 percent said maybe, and 3 percent said they would not.

*Table 5.20 Materials used in the living room and the attractiveness of natural materials (%, n=376)**

Type	Synth.carpet	Wool	Wood/laminate	Cork	Linoleum	Vinyl	Stone	Total
Possession	12	5	45	5	6	7	20	100
Attractive	-	21	81	23	30	-	33	188*

** more than one answer possible; - not asked, no natural material*

The answer about types of materials in the living room was recoded to 0: synthetic materials and 1: natural materials (wool/wood/laminate/cork/linoleum/stone). This dichotomous use variable was positively related to the willingness to buy natural materials in the future (τ_c: .19; p<.000, n=373). The attractiveness of the different natural materials was not related to either this use variable or to willingness to use natural materials in the future.

In short, willingness to change to natural materials was not clearly related to the attractiveness of the different natural materials, but more willingness was related to the use of natural materials. Perhaps restricting factors such as cost, availability, and familiarity with use played a greater role than preferences.

5.5.3 Activity category Clothing

Households were asked how long textiles or clothing were used before washing, as well as about washing and drying behaviour.

- For clothing and textiles, respondents were asked how many days blouses, jeans, sports clothing, bedding, towels were used before washing. The reduction option involved how many days longer these articles could be worn or used.
- For washing behaviour, respondents were asked how many loads were washed per week and at which temperatures the white, coloured, and dark laundry was washed. The reduction option involved which of these three types of laundry could be washed 10°C lower (dichotomous) and which measures were taken when the laundry turned out not to be satisfactorily clean (open question).
- For drying behaviour, respondents were asked whether households had a dryer, which type (air-vented or condenser dryer), how often the dryer was used per week or per month, and how full the dryer was loaded on average (interval, 5 points scale). The reduction option was whether the respondent was willing to use the dryer more selectively for environmental reasons, and how this would be done (no change, fewer articles, fewer dry cycles, or both; 4 points ordinal scale with increasing energy friendliness). Also investigated was how large the portion of the laundry would eventually be that was no longer dried in the dryer (interval, 5-point scale). Respondents were also asked whether they were willing not to replace the dryer when it no longer functioned.

Using textiles longer and laundering behaviour

The number of days that textiles were used plus the number of extra days that households would be willing to use the textile prior to washing are shown in Table 5.21.

Table 5.21 Number of days that textiles are used plus the number of days that textiles can be used longer before washing (n=375)

	Blouses	Jeans	Sports clothes	Bedding	Towels
Average use days (s.d.)	2.1 (± 1.7)	4.3 (± 3.9)	1.5 (± 1.9)	10.4 (± 5.1)	2.6 (± 2.3)
Average extra days	+ 0.3	+ 0.1	+ 0.1	+ 0.5	+ 0.2

Most households (91 percent) indicated one or more types of articles that could be used longer. Households that were willing or not willing did not differ in the number of days that textiles were used. Nevertheless, use days for different articles were positively and significantly related to each other (R between .11 and .70; p:.000). The extra numbers of days that articles could be used were also significantly and positively related to each other (R between .27 and .53; p:.000).

Laundering and drying behaviour is summarised in Table 5.22.

Households with an air-vented dryer or a condenser dryer washed more often than did those without a dryer (ANOVA, Scheffé, F: 6.9, p:.000, n=284, in Table 5.22 marked with */**). Households with an air-vented dryer had higher washing temperatures for dark laundry than did those with a condenser dryer (ANOVA, Scheffé, F: 4.6, p<.01, n=229, Table 5.22: */**).

Table 5.22 Characteristics of wash- and drying behaviour, broken down for dryer possession (n=376)

	Penetration rate (%)	Average wash frequency/week (± s.d.)	Average drying frequency/month (± s.d.)	Average wash temperatures (°C) (± s.d.)	
Condenser dryer	22	6.4 (± 2.9)*	14.9 (± 12.3)	white	56° (± 15.5°)
				coloured	41° (± 7.5°)
				dark	37.5° (± 5.6°)*
Air-vented dryer	41	6.9 (± 3.2)*	17.8 (± 13.3)	white	57.3° (± 14.4°)
				coloured	41.5° (± 8.2°)
				dark	40.1° (± 7.1°)**
No dryer	37	5.5 (± 2.9)**	n.a.	white	56.3° (± 14.1°)
				coloured	40.6° (± 8.1°)
				dark	38.3° (± 6.6°)

/: in a column differs * significantly from ***

The following relations were found for different laundering practices:

- Wash frequency and dryer possession were positively related (τ_c:.17; p:.001, n=376), as were washing and drying frequency (Pearson's R: .64; p:.000, dryer owners n=231);
- Wash frequency and dryer possession were related to the use time of articles. The use time of blouses and towels was negatively related to the wash frequency: the more days these were used, the lower the wash frequency (τ_c respectively -.15 en -.22; p:.000). Dryer

possession was negatively related to the use time of jeans and towels (τ_c respectively -.16 en -.15; p:.000);
- Drying frequency was related to the use time of articles, but τ_c and Pearson's R were low and barely significant;
- Wash temperatures were not significantly related to wash frequency, dryer possession, drying frequency, and the use time of articles;
- Wash temperatures were related to each other; when white laundry was washed at higher temperatures, coloured and dark laundry were washed hotter as well (respectively R: .20 en R:.17; $p<.01$, n=364). This was also valid for coloured and dark laundry (R: .49; p:.000, n=364).

However, willingness to use textiles longer was not significantly related to wash frequency, dryer possession, drying frequency, and wash temperatures.

Wash temperatures

In Table 5.23 the willingness to wash the white, coloured and dark laundry at 10°C lower temperatures is shown.

Table 5.23 Willingness to lower the wash temperature by 10°C for different types and combinations of three types of laundry (%, n=376)

White	Coloured	Dark	None of the types
8.1 (n=31)	3.4 (n=13)	5.2 (n=20)	73 (n=273)
White + coloured	White + Dark	Dark + coloured	All 3 types
2.1 (n=8)	0.3 (n=1)	5.5 (n=21)	2.4 (n=9)

Seventy-three percent of the households did not want to change wash temperatures at all. Households willing to lower the wash temperatures for coloured laundry were relatively often willing to do so for dark laundry (R:.52; p:.000) and to a lower extent for white laundry as well (R:.24; p:.000).

The following relations were found between willingness and use: Willingness to lower the wash temperatures was not related to wash frequency, dryer possession or drying frequency, use time of textile articles, willingness to use articles longer, or the wash temperatures. There were five exceptions:
- Households that were willing washed their white laundry on average at 67°C (13 percent of the households); households that were not willing washed on average at 55°C (87 percent) (ANOVA, F: 31.3; p:.000, n=368);
- Households willing to wash coloured laundry at a 10°C lower temperature washed it at higher temperatures (on average 43°C) compared with households that were not willing to do so (on average 40°C) (ANOVA, F: 5.5, p:.02, n=366);

- Households willing to wash the dark laundry 10°C lower washed it at higher temperatures (on average 42°C) compared with those that were not willing (on average 38°C) (ANOVA, F: 9.8, p:.002, n=362);
- Households willing to wash white, coloured, or dark laundry 10°C lower were prepared to wear upper clothing 0.2, 0.25 and 0.3 days longer, respectively, compared with households that were not willing to launder at lower temperatures (ANOVA, F: 4.0, 6.4, 9.1; p: <.05);
- Households willing to wash the white laundry 10°C lower wore blouses longer (on average 2.7 days) compared with households that were not willing to do so (on average 1.9 days) (ANOVA, F: 7.2, p:.007, n=362).

The question about measures taken when the laundry was not satisfactorily clean was answered by all households, and not only by those that were prepared to wash any of the laundry types at a 10°C lower temperature (n=103), see Table 5.24. Relatively more households that were willing to wash at lower temperatures would wash at higher temperatures (57 percent) or take another measure as well (13 percent) if the laundry was not sufficiently clean.

Table 5.24 Willingness to wash 10°C lower and measures when laundry is not sufficiently clean

	No change (%)	Wash at higher temperatures (%)	Other measures (%)	Higher + Other (%)
Not willing 10°C lower (n=273)	12	38	41	9
Willing to wash 10°C lower (n=103)	1	57	29	13
Total sample (n=376)	9	44	38	9

Other measures taken by households in the sample are listed in Table 5.25; 168 households specified 177 measures.

Table 5.25 Measures to compensate 10°C lower wash temperatures (% of mentioned measures (frequency = 177) by n=168 households) if the laundry is not sufficiently clean

Measure to compensate lower washing temperatures	(%)
Different washing powder	33
Spot treatment	27
Soak (sometimes in combination with other measures)	9
Pre-wash in machine	8
Wash item again	8
More washing powder	3
Think 'it is not important enough'	3
Load less	3
Other comments: bleaching (2)/shorter use of articles (3)/wash with longer programme (1)/5°C higher (1)/pre-wash by hand (2)/sun bleach (1)/wash amplifiers (1)	6

The measures most used were 'changing to other washing powder' and using detergents for 'spot treatment'. Measures that probably cost more energy because more water was involved were the next most popular ones: soaking, pre-washing, and washing the item again.

For households willing to wash at a 10°C lower temperature, the measure 'different washing powder' was also the most popular (21 of the 42 measures), followed by 'spot treatment' (13 of the 42 measures). 'Soaking, pre-washing, and washing again' were mentioned 5 times; 'bleaching', ' it doesn't matter' and 'loading less' were each mentioned once.

In short, households willing to wash at lower temperatures washed their white, coloured, or dark laundry at 12, 3, and 4 °C higher temperatures, respectively; they were also willing to wear upper clothing a little longer. There were no other correlations with use variables.

Tumble dryer

How households used their tumble dryers is shown in Table 5.26.

Table 5.26 Use of the tumble dryer (%, n=234)

Dryer not in use	¼ full	½ full	¾ full	Full	Very full
1.7%	1%	11.6%	28.4%	53.8%	3.4%

The question of whether the household was willing to use the tumble dryer more selectively for the environment was answered with 'no' by 31 percent of the households; 46 percent answered 'maybe' and 23 percent answered 'yes'. The manner of selective tumble drying is shown in Table 5.27.

Table 5.27 Type of change for a more selective use of the tumble dryer (%, n=228) and drying frequency (cycles/month) broken down by willingness to change

Willing to change?	No change %	Fewer articles per cycle %	Fewer cycles %	Fewer articles and cycles%	Total %	Drying frequency cycles/month
No (n= 70)	31	-	-	-	31	13.9
Maybe (n=105)	4.3[23]	1.8	30.7	9.2	46	19.4
Yes (n=53)	2.6[4]	2.2	15.7	2.5	23	17.0
Total (n=228)	37.9	4	46.4	11.7	100	16.8

Households that answered 'no' to the question of selective use were more consistent: they give no answer other than 'no change'. The drying frequency per month between 'maybe' and 'yes'

[23] Inconsistent answers might mean that the households had other measures in mind to use the dryer more selectively but for which no answer category was available. For example: in the case study Textile Care (Chapter 4) respondents reported using shorter dry programmes or partly drying the laundry and then hanging it out to dry further.

was not significantly different (ANOVA, F: 1.5; p:.22), but there was a significant difference between 'no' and 'maybe/yes' (ANOVA, F: 6.5; p<.02). Drying frequency was significantly positively related to how the dryer could be used more selectively (τ_c: .22; p:.000, n=222)[24]. This meant that households willing to lower both 'dry cycles' and 'dry cycles and articles' had a higher drying frequency (19.2 times per month) compared with households (14.6) that did not want to change or were only willing to lower the number of articles that were dried.

The percentage of households that answered 'maybe' and 'yes' (respectively 4.3 percent and 2.6 percent, see Table 5.27), but nevertheless would not change the number of articles and cycles, increased to 11.4 percent when asked specifically what part of the laundry was no longer dried in the dryer (see Table 5.28).

Table 5.28 The part of the laundry that is no longer dried in the dryer when the machine is used more selectively; broken down by willingness (% of dryer owners: n=228)

Willing to change?	No change	Less than ¼	¼ - ½	Approx. half	½ - ¾	¾ - all
No (n=70)	31					
Maybe (n=105)	5.7^4	18.4	12.2	7.9	1.3	0.5
Yes (n=53)	5.7^4	5.7	4.3	3.9	0.5	3
Average drying freq.	13.6	22.6	19.4	18	14	6.9

The table shows that households with a higher drying frequency nevertheless only expected to reduce half or less of the tumble dried laundry (ANOVA, F: 5.08; p:.000; n=220).

For the group that was perhaps willing to use the dryer more selectively, no significant relations existed between the use of the dryer (loading, frequency) and the way the dryer could be used more selectively (how, which part).

Finally, of households with a dryer, 14 percent were willing not to replace the dryer. This willingness was related to a lower drying frequency (Pearson's R: -.34; p:.000, n=232). Households that were not willing had an average drying frequency of 18.6 times per month; those that were willing had a drying frequency of 6.1 times per month.

In short, willingness to change to more selective dryer use was related to a higher drying frequency. The expected change for households with a low drying frequency was higher than for households with a higher drying frequency. Willingness to 'not replace' the dryer was related to a lower drying frequency.

24 Using the dryer more selectively is a 4-point ordinal scale regarding increasing energy friendliness.

5.5.4 Activity category Transport

For the category Transport, households were asked how many cars they possessed, how much the most frequently used car weighted, and how many kilometres per year were driven in total. Seven reduction options were investigated in terms of whether they were sufficiently attractive for the household to do something for the environment (dichotomous). The options were: a shared car through a company or with other households, a lighter car, driving less, making more use of public transport, using a bicycle or a moped, or getting rid of the car altogether.

The type of car ownership is shown in the following table, together with the average kilometres travelled per household in a year.

Table 5.29 Car possession (%) and mileage (kilometers/year.household) (n=376)

	None	Shared (household)	Shared (company)	1	2	3 or more
Car possession %	14.5	3.5	1.1	62.5	16.4	2.0
Km/year. household	-	12362	14250	15913	38432	35714

For the following analyses, households were selected that possessed one or more cars (80.9 percent) because too little data were available on car weight for households with a shared car.

- The average weight of cars that were not shared was 1040 kg ± 229 kg (n=216). The average weight of cars did not differ significantly for households that possessed one, two, or three cars (n=304);
- On average, 21202 km/year were driven (± 17511, n=293). Households that had two or three cars drove significantly more kilometres than did households with a shared car or one car (ANOVA, Scheffé, F: 28.8; p:.000, n=298);
- A positive relation was found between the number of kilometres and the weight of the most frequently used car (τ_c :.23; p:.000, n=292).

For car owners (80.9 percent), preferences for options were not related to use (number of cars, weight, and kilometres).

For the total sample, with the environment in mind, households chose on average 1.6 transport alternatives (see the following table). There was no significant difference between the different types of car owners and the number of options they chose (ANOVA, F: 3.3; p>.01, n=370), see Table 5.30.

Table 5.30 Number of options chosen by different groups of car owners

None*	Shared (household)	Shared (company)	1	2	3 or more
1.9	2.2	1.7	1.6	1.4	1.2

However, there was a difference in the type of options chosen (see Table 5.31). In this table the percentage of households are shown that did not own a car but chose a shared car through a company (4.3 percent). Relatively popular per type of car ownership were bicycles and mopeds (for non-car owners, a car shared with another household (for owners of one and two cars), driving less (for owners of one, two, and three cars), and cars shared through a company or household.

The following analyses were done individually for each reduction option. Households without a car or with a car shared with another household or through a company chose the option 'shared car through a company' more often than did households with one or two cars (ANOVA, Scheffé, F: 10.0, p:.000, n=372). The option 'shared car with household' was chosen more often by households without a car than by those with one or two (ANOVA, Scheffé, F: 5.9, p:.000, n=372).

Table 5.31 Preferences for transport options broken down by car possession (%)

Reduction options**	Car possession						Total
	None*	Shared (household)	Shared (company)	1	2	3 or more	
Shared (company)	15.4	17.3	37.5	4.8	4.7	-	7.5
Shared (household)	19.2	10.3	25	7.4	7.2	-	9.6
More public transport	22.1	13.8	-	13.9	8.2	11.1	14.3
Bicycle/moped	25	24.1	12.5	28.8	29.4	22.2	27.7
Lighter car	4.8	10.3	12.5	13.9	17.6	22.2	12.7
Get rid of car	-	6.9	-	2.1	3.5	-	2.1
Drive less	13.5	17.3	12.5	29.1	29.4	44.5	25.9
Total	100	100	100	100	100	100	100
(mentioned frequency)	(f=104)	(f=29)	(f=8)	(f=375)	(f=85)	(f=9)	(f=610)

** inconsistent answers; this might mean that households either used cars, e.g. through hiring, borrowing, or asking for lifts, or that they wanted more mobility*

*** more answers possible*

For car owners, preferences for options were not related to use (weight, etc.). Using a bicycle, sharing a car, and driving less were relatively popular, depending on the type of car that was owned. Differences in preferences between households with and without a car were larger than for households with a car between them. This in particular was valid for the options 'shared car with another household' or 'through a company'. Car owners chose these options less often than did households without a car (both τ_c: -.17; p:.000, n=372).

5.5.5 Activity category Social Contacts

The activity category Social Contacts was investigated in terms of how often the household bought flowers for others and how often this activity could be replaced by eight different options (dichotomous). These options were plants, ecologically grown flowers, CDs, CD or book vouchers, other gift vouchers, sweets and chocolates, wine or other alcoholic beverages, and fruit or fruit juices.

On average, households bought flowers 11.7 (±8.8) times per year for others and 12.5 (±15.0) times for themselves. Flowers as gifts could be replaced 6.7 (±5.6) times per year by other presents. Preferences for alternatives are mentioned in Table 5.32.

*Table 5.32 Preferences for alternatives in % per option**

Plants	Eco-flowers	CDs	CD or book vouchers
57	21	21	39
Gifts voucher	Sweets	Alcoholic beverages	Fruit juices
46	43	48	13

** More options possible; added up to 288 percent*

On average, the households chose 2.9 alternatives, among which plants, alcoholic beverages, and gift vouchers were the most popular.

When more flowers were bought for others, the number of times that flowers could be replaced was higher as well (Pearson's R: .65; p:.000; n=331); nevertheless, the percentage of replacement was lower. Households that bought flowers for others 0 - 5 times per year (average 3.4 times) indicated that they could replace on average 69 percent (2.8 times), whereas households that bought flowers as gifts more than 21 times per year (on average 32.7 times) indicated that 45 percent (14.9 times) could be replaced (ANOVA, Scheffé, F: 4.16; p <.01, n=323). There was no relation between the preferences for alternatives and the frequency of buying flowers for oneself or for others, with one exception: When households were prepared to buy gift vouchers for CDs or books instead of flowers for others, they bought flowers for themselves more often (15.1 times/year) than did households that were not prepared to do so (10.8 times/year) (ANOVA, means, F: 7.3, p:.007, n=373).

Twenty-five households mentioned other alternatives for flowers: for example, bath products, earthenware, books, cosmetics, hand-made gifts, candles, tea, items from third-world shop, toys, articles on wish lists, and trinkets.

Evidently, when consumption was higher the number of times households were willing to replace flowers for others with other gifts was higher, but the percentage was lower. No relation existed between use and the type of preference. Plants, alcoholic beverages, and gift vouchers were popular.

5.5.6 Activity category Leisure Time

Respondents were asked how often the households went on holiday during the year 1998, which countries were visited, and for how many days. They were also asked what types of transport were used (dichotomous) as well as what types (eight) of accommodation. The suggested reduction options included vacations closer to home, not 'often, shorter and nearer' but 'less often, longer and further away', or using a tent instead of staying in a cottage or in an apartment (dichotomous).

Results for number, days, means of transport, and type of accommodation are shown in Tables 5.33 and 5.34.

Table 5.33 Number and length (in days) of holidays in 1998

	Number of holidays	Average number of days	Not on holiday
Total sample (n=376)	1.5 (± 1.1)	16.2 (± 12.7)	18 percent
Holiday sample* (n=309)	1.8 (± 0.9)	19.5 (± 11.4)	n.a.

** households that went on holiday*

Households used different means of transport (on average 1.6 types) and accommodation (on average 1.4 types) on their holidays in one year.

Table 5.34 Use of transport and accommodation on holidays (%, n = 309)

Car	Airplane	Bus	Boat	Bicycle	Train
87	24	9	7	19	11
Hotel or pension	Tent	Cottage	Apartment	Youth hostel or travellers hut	Caravan or camper
29	26	40	21	3	25

Five of the households that did not go on holiday nevertheless mentioned that they were away for three or four days, by car, by bicycle, on foot, or by bus or train. No accommodation was mentioned, so this might have involved 'days out' and possibly spending the nights in the houses or apartments of family and friends.

Table 5.35 Willingness to change to three holiday reduction options (%)

	Closer to home	Further-Less often	Tent instead of cottage or apartment
Total sample (n=376)	18	18	18
Holiday sample (n=309)	17	17	19
Not on holiday in 1998 (n=67)	23	19	14

In particular households that took no vacation in 1998 were prepared to holiday 'closer to home'. This might be of negative influence on the potential of energy saved by the total sample. However, these households might have travelled to far destinations in other years.

For households that went on holiday, no relation existed between the number of times, the number of days, the type of transport or accommodation, and the willingness to change to one of the reduction options (ANOVA, p>.05), with four exceptions:

- When households were more often prepared to switch to a 'tent instead of a cottage or an apartment', they more often went on a holiday with a bicycle (29 percent), and stayed in a tent (38 percent), in an apartment (33 percent), or in a travellers hut (7 percent) as compared with households that were not willing (respectively, 17%, 23%, 19%, 0%; ANOVA, p:<05, n=307).

Preferences for holiday alternatives were not related to frequency and length. The tent option was related to bicycle and to low-cost 'outdoor' type holiday accommodation and was thus preferred by households that used that type of accommodation anyway.

5.5.7 Activity category Large Purchases

Respondents were asked whether the household had bought solar boiler or planned to do so in the future (no/yes/maybe; trichotomous). Regarding energy-efficient appliances, it was asked 'if you could, which possibilities could you or would you choose for the environment' (more answers possible). For this, five possibilities were given, of which four have been discussed:

- 'smaller fridge', 'smaller freezer', and 'no replacement of the freezer' were analysed for the activity category Food;
- 'no replacement of the dryer' was analysed for the activity category Textile Care.

The fifth option was whether, in general, energy-efficient appliances with the eco-label A (e.g. dishwashers, dryers, washing machines, fridges, freezers) were acceptable (no/yes).

Table 5.36 Possession and willingness to use a solar boiler and energy-efficient appliances in the future (%, n=376)

	Possession	Maybe in the future	Not in the future either
Solar boiler	3	41	56
Energy-efficient appliances	not asked	95	5

Ninety-five percent of the households thought that buying 'energy-efficient appliances' was acceptable in the future; 41 percent thought so with regard to solar boilers.

For the solar boiler (possession, willingness) and energy-friendly appliances (willingness), the relations to other large appliances were investigated: possession of dishwasher, dryer, and freezer, and the willingness not to replace the dryer and freezer and to buy a smaller fridge and freezer.

Households with a solar boiler:

- Owned a dryer less often (on average 0.28) than households without a solar boiler (on average 0.69) (ANOVA, Scheffé, F: 3.9, p:.021, n=303);
- Were more often prepared not to replace the freezer (0.18 times) than households without a solar boiler (on average 0.02 times) (ANOVA, Scheffé, F: 3.9, p: .021, n=294).

No relations existed between willingness to change to a solar boiler, possession of large appliances, and willingness to accept options regarding them.

Households that found energy-efficient appliances acceptable:
- Were less willing to 'not replace the dryer' (0.42 vs. 0.12) and 'not replace the freezer' (0.17 vs. 0.4) (ANOVA, respectively F: 9.5, F: 5.2, p :< .05, n=294).
- Were less often willing (0.42 vs. 0.9) to replace the freezer with a smaller one (ANOVA, F: 13.5, p: .000, n=294).

It appeared that there were different types of willingness: actual sacrifices in possession and purchase of large appliances (solar boiler, no dryer, no replacement of freezer) vs. the same availability in use features but with less energy requirement (energy-efficient appliances but not reducing types and capacity of appliances).

5.5.8 Attractiveness vs. willingness to change

A list of 31 reduction options was presented at the end of the survey. Households were asked to select the four most attractive that they would be prepared to try. This meant that each reduction option had a theoretical chance of 12.9 percent (=4/31*100 percent) of being chosen, if there were no differences in preferences among the households.

As described previously, households were asked about their willingness to change with regard to each separate reduction option (Willingness to change). The two types of acceptance (Willingness and Attractiveness) were summarised and are presented in Table 5.37.

Options with extreme 'Willingness to change' percentages were 'get rid of the car' (3.4 percent) and 'energy-efficient appliances' (95 percent).

*Table 5.37 Willingness to change per reduction option and for a choice of four out of 31 reduction options (theoretical chance of 12.9%)**

Attractiveness	Response to willingness >25%	Response to willingness 10-25%	Response to willingness <10%
Choice of 4 out of 31 options: > 12.9%	Energy-saving light bulbs Energy-efficient appliances Pre-rinse dishes cold Plants instead of flowers Gifts instead of flowers Conserved veg. iso frozen Conserved veg. iso fresh Water-saving shower heads	Heat less in daytime when nobody is home Heat less at night Use the dryer more selectively Green electricity	Heat less in daytime when someone is home Heat less in the evening Solar boiler
Choice of 4 out of 31 options: < 12.9%	Natural floor materials Drive less More use of bicycles and mopeds Replace meat Wash at lower temperatures Use textiles longer	More public transport Lighter car Eco-flowers instead of flowers Not replace the dryer Smaller freezer Holidays closer to home H. longer/further/fewer Tent iso cottage/apt.	Shared car (company) Shared car (households) Get rid of the car Not replace the freezer Smaller refrigerator

** 'Heat less' was specified in four options in the survey and in this table, and was asked as one option in the list of 31 options from which four could be chosen*

As seen in the upper leftmost cell, apparently the most popular reduction options were small, practical, and concrete indoor changes. These options were not too personal, did not require too much effort to start or to acquire, and demanded relatively low sacrifices in the use phase, sometimes none at all.

In general, options in the upper row were not too personal but nevertheless mostly related to indoor activities and to the house. It appeared that options in the lower row were more related to personal preferences (holidays, floor materials), taste (meat), norms such as hygiene (wearing and washing of textiles), and family life and its organisation (transport, cooling and freezing). Options in the lower row were more outward oriented as well, so perhaps outward appearance or status also played a role.

Seen in the table from left to right, the options were increasingly difficult: those in the first column could be carried out relatively easily; those in the second column required some effort, and an adjustment had to be made; those in the third column demanded large sacrifices.

5.5.9 Summary and discussion of the energy-saving potential

Summary of preferred options and the relation between use and willingness

How use and practices were related to the willingness to accept reduction options is discussed in this section where it is described how households with differences in willingness differed in their practices. When summarising the results it was possible to distinguish four types of relations (see the categorisation in Table 5.38).

Table 5.38 shows that relations existed between use and willingness for nearly two-thirds of the reduction options and that these relations could be of different types:

- Options in the category 'more willingness is related to more use' have energy-saving potential. The more so because most of these options were the most popular as well (compare Table 5.37 and the upper leftmost cell). Apparently there was room to decrease the use, which influenced popularity;
- Second-category options are not expected to have high energy-saving potential, either because of the relation to use or because the popularity was low;
- Third-category options are expected to give minor energy reductions because the options were closely related to existing preferences;
- Fourth-category options were possibly related to other use variables.

Table 5.38 Categories of relations between use and willingness*

Type of willingness	Use variables
More willingness is related to more use	Related to the use variable
Pre-rinsing more often with cold water	More pre-rinsing with warm water
Smaller freezer	More freeze capacity
Replace pre-frozen vegetables by conserved veg.	Higher frequency pre-frozen vegetables
Wash temperatures 10°C lower	Higher wash temperatures
More selective dryer use	Higher drying frequency
Willingness to replace flowers	Higher frequency flowers for others
Heating 1°C less in daytime and at night	Higher heating day and night/gas use
More willingness is related to less use	Related to the use variable
Smaller refrigerator	Indication: lower use intensity of capacity
Get rid of dryer	Lower drying frequency
Green electricity	Lower electricity use
More of the same or different	Related to the use variable
Replace beef or pork meat by alternatives	Types of meat
Use (more) energy-saving light bulbs	Possession of energy-saving light bulbs
More natural floor materials	Types of floor materials
Tent instead of a cottage or apartment	Types of accommodation and transport
Change to a shared car (company or household)	Type of car ownership
Willingness has no relation to use	Investigated variable
Not replace the freezer	Number, capacity, used cap., no. prod. types
Replace fresh vegetables in winter by conserved veg.	Consumption frequency of fresh vegetables
Use textiles longer before washing	Number of wearing days
Kind of replacements for flowers (plants, gifts etc.)	Frequency buying flowers for others
Heating 1°C less in the evening	Heating temperatures in the evening
Buy a water-saving shower head in future	Gas use
Drive less; change to a lighter car	Kilometres/year; weight of the car
Get rid of car; more public transport or bicycle/moped	Number of cars; kilometres/year; weight
Buy a solar boiler in future	Gas use
Energy-efficient appliances	--

** Whether the correct type of use was chosen with which to relate willingness is a topic for discussion.*

Estimation of energy-saving potential

The eventual energy-saving potential depends on the willingness to change and on the energy consumption associated with actual behaviour. In the following, which options were the most popular is examined, as well as how to interpret some of the data.

The following options have the highest reduction potential because willing households were also relatively more energy unfriendly in their behaviour:

- Pre-rinsing more with cold water (in households that do not have a dish washer);
- Using the dryer more selectively (in households that have a higher drying frequency);
- Heating at lower temperatures during the day when nobody is home and at night;
- Replacing flowers with plants and gifts in households with a high frequency of buying flowers for others;
- Replacing pre-frozen with conserved vegetables in households that use pre-frozen vegetables often and also store them in the freezer.

Energy-saving light bulbs also have an energy-saving reduction potential because of their relative high popularity. In particular, extra attention might be needed for households that have no energy-saving light bulbs at all.

Popular options for which no relation to use variables existed were:

- Water-saving shower heads;
- Energy-efficient appliances;
- Conserved vegetables in place of imported or greenhouse vegetables. Apparently conserved vegetables were generally popular to replace either the pre-frozen variety or those imported or grown in greenhouses.

Not replacing or getting rid of an appliance or the car was much more unpopular compared with changing or reducing one's use of it.

Some questions might have been misunderstood. This was probably the case for meat replacement and for the replacement of pre-frozen, greenhouse grown, and imported vegetables with conserved vegetables. The replacement frequencies were sometimes higher than the actual consumption, which indicated that the reported frequency was the maximum with which the alternative could be consumed.

For three reduction options, comments could be made on the energy-saving potential estimation:

- For heating, the relation between behaviour and willingness to change was likely to have a physical aspect. The households willing to heat less in daytime when nobody is home and at night had up to 2°C higher average heating temperatures. These were the reported 'thermostat' temperatures, not the actual temperatures. Higher reported thermostat temperatures were related to higher gas consumption, but the respondents' willingness to heat less was not related to gas consumption. This positive relation of thermostat

temperatures to gas consumption likely reflected the physics (e.g. insulation) of the house and the efficiency of the heating system, and thus the minimal warmth needed to heat the house. This would mean that higher reported thermostat temperatures do not necessarily lead to higher room temperatures. Households willing to change their behaviour heat at a higher temperature, but apparently it is not really necessary to heat the house for physical comfort in the daytime when nobody is home, or at night.
- The use of natural floor materials was already high: 81 percent of the households had natural floor materials in their living rooms, so this high percentage made the reduction option seem redundant. Either households mistook their synthetic carpets for wool, or the living room was indeed furbished with natural materials and attention should be shifted to other rooms in the house in order to save energy.
- Households without cars, those that shared cars, and those that had not taken holidays in 1998 chose reduction options that in fact required more energy than their reported behaviour. Thus, there was a desire for mobility and holidays. If flexible solutions (especially in the case of transport) were available, these groups might apply these as well, leading to an increase in energy use.

The following options could not be clearly categorised:
- Holidays further away, longer, and less often; this meant recoding the destinations into distances and combining distances, length, and frequencies of holidays into types;
- Holidays closer to home (likewise for distances);
- Energy-efficient appliances.

Either the use could not be further differentiated or a more extensive analysis of the use was needed.
Taking into account the above, the data is useful to estimate energy-saving potential in family households. However, this was not done for this thesis.

5.6 Results at the organisational level

This section continues with results at the organisational level. Firstly, several composed variables and scales are described that are assumed to influence willingness to change and the energy friendliness of use behaviour.
§5.6.1 describes how these concepts were developed on the basis of the initial data. The composed variables and scales are described in the following order:
- Several aspects of the organisation of household activities (composed variables);
- Several aspects of the environmental friendliness of a household and its behaviour (composed variables and scales);
- Willingness to change (composed variable).

Secondly, analyses are carried out for construction of the composed variables reliability. Using Cronbach's alpha, the item-total correlations and the score on Cronbach's alpha when items were deleted are checked in order to decide which items were not included.

Thirdly, the composed variables and scales are analysed in relation to each other and to demographic and household characteristics (§5.6.2). In §5.6.3. the composed variables and scales are used in a regression analysis to explain the variance in willingness to change and in the energy friendliness of use behaviour.

5.6.1 Composing aggregated variables and scales

Aspects of the organisation of household activities

The composed variables about aspects of the household organisation were constructed with the initial data about household activities. These were related to the following 11 activity categories:

- Food
- Clothing and Shoes
- Care and Guidance
- Other Activities and Help
- Organising and Planning
- Larger Purchases (furniture, appliances, etc.)
- House
- Daily Shopping
- Work and Study
- Leisure Time
- Social Contacts

A more precise description of these activity categories is given in §5.2.1.

The following were constructed: Combining, Frequency of Confer, Task Division, Pleasure, Importance, Time, Home Production, Use of Commodities, and Contracted Time.

- *Combining: carrying out activities simultaneously*

The ability to carry out several activities simultaneously (multi-tasking) may influence the capacity to accept related energy reduction options. Therefore the variable Combining was constructed. The frequency with which different activity category tasks were executed simultaneously was taken as a measure for Combining. This frequency was asked for ten combinations of tasks from nine activity categories. These ten combinations were chosen because they seemed most likely to be carried out simultaneously. (The categories Other Activities and Help and Large Purchases were not expected to be combined with other activities). In the questionnaire it was asked how often combined activities took place: a couple of times per day, per week, per month, or per year (ratio-scale). Results were recalculated in 'per year'. These ten combination frequencies were added to form a new variable, Combining, which gave a general impression of the extent to which a household combined tasks (mean 1633, s.d. 1252, minimum 39, maximum 10455). Because no background information was available, the theoretical possible frequency was not taken into account, nor were the combinations weighted.

Table 5.39 Combining: carrying out activities simultaneously

Combination of activities	Average frequency per household per year (s.d)
Cooking with housework	262 (266)
Dinner with friends (also friends of children)	48 (105)
Cooking/dishwashing with guidance of children	354 (385)
Cooking with reading/TV/music	216 (276)
Cleaning with laundering	217 (226)
Laundering with reading/TV/music	161 (235)
Daily shopping with services	106 (143)
Daily shopping with transport work/study	73 (140)
Transport work/study with transport children	90 (219)
Daily shopping with transport children	89 (193)

Note that the standard deviation—compared with the mean—for the composed variable is relatively smaller than for the individual items. A reliability analysis for these ten combinations gave a Cronbach's alpha of 0.75 for standardised items. The reliability analysis showed that the ten items formed a reasonably good scale.

Results for the following composed variables are summarised in Table 5.48.

- *Frequency of Confer*

The frequency with which partners or household managers discussed household activities with partners or children is likely to influence the acceptance of reduction options. The idea was that—despite the differences in needs, goals, and resource allocation (see §5.2.1)—more interaction between the household members about tasks could lead to more and easier change in the way tasks were done, which could include a change in environmentally friendly direction. Therefore, the variable Frequency of Confer was constructed that measured how often household members discussed the ten categories of household activities. In the questionnaire this was asked on a 4-point ordinal scale: once up to several times per day (score 4), once up to several times per week (3), per month (2) or per year (1), or not applicable (no partner) (0). The activity category Organising/Planning/Confer was not included, as it would have been a meta-question about Confer, which could have been confusing.

Cronbach's alpha for the ten items was high: 0.97. The variable Frequency of Confer was constructed by adding the scores of the ten items per household (mean 21.1, s.d. 10.8, minimum 0, maximum 40). The items were not weighted.

In 16 percent of the households no partner was present. Some households specifically mentioned on the back of the questionnaire that they included their children, with whom conferring took place. Because of the idea behind Frequency of Confer (change was more likely with more conferring), these households were included.

Most respondents stated that, on average, activities were discussed once to several times per month. Households with two adults discussed their activities daily (13 percent), weekly (35 percent), monthly (20 percent), or yearly (15 percent); Care and Guidance issues regarding the children were discussed most often (daily to several times per week); Social Contacts, Leisure Time, and daily purchases were discussed weekly; and the purchase of large items, such as furniture and appliances, was discussed least (once to several times per year).

- *Sharing activities and task division between partners*

Similar to the frequency of discussing activities, the task division between partners might influence the acceptance of reduction options. The idea was that when tasks were shared more it might lead to increasing awareness about how things could be done differently, or lead to a feeling of shared responsibility for the environment in general.

Therefore the variable Task Division was constructed. This was the division of household activities among household members, in particular between partners. The tasks could be done by 0 percent up to 100 percent by one partner, and consequently from 100 percent to 0 percent by the other. This was measured with a 7-point interval scale (100 percent by women [score 1] - 80/20 - 60/40 - 50/50 - 40/60 - 20/80 - 100 percent by men [score 7]). Tasks could also be executed by household help or children. Most households were families, but one-parent families were also present in the sample, possibly with a partner who did not live in the house but partly joined in household activities.

For the previously mentioned eleven task categories, the data were added per household to form the variable Task Division (mean 31.8, s.d. 10.7, minimum 11, maximum 77). Cronbach's alpha was 0.89, indicating that the eleven items measured task division in much the same way and therefore could be used in a scale.

On average, the respondents divided their activities. In general, 60 percent of tasks were done by women and 40 percent by men. Activities relating to clothing and daily shopping were most often carried out (80 up to 100 percent) by women, in 87 and 72 percent of the households, respectively. Activities relating to work and study were most often carried out by men: 20 percent women, 80 percent men (27 percent of the households). The most equally divided activities were those relating to Leisure Time, Other Activities and Help, and Large Purchases.

- *Pleasure experienced in activities and household tasks*

The pleasure experienced in activities can influence the acceptance of reduction options. Tasks that are enjoyed possibly offer an incentive to consider change, even when the change requires more effort or time; less enjoyable tasks possibly offer an incentive for change when the change means more efficiency. In this thesis, pleasure in household tasks measured how the respondent felt about executing tasks in the eleven activity categories, again on a 5-point ordinal scale (very pleasant [score 5], pleasant, neutral, not so pleasant, very unpleasant [score 1]).

Cronbach's alpha for these 11 items was 0.69, indicating that the items could be used as a scale. The variable Pleasure was constructed by adding the scores per household for the 11 items (mean 40.6, s.d. 3.9, minimum 30, maximum 53). The items were not weighted.

On average, the respondents scored household activities as 'neutral' or 'pleasant' (in total for food activities: 84 percent of the households, daily purchases: 83 percent, work: 84 percent, other activities and help: 85 percent, organisation and planning: 84 percent and large purchases: 79 percent). The least enjoyed activities concerned Clothing and House (both scored 'very unpleasant' by 22 percent of the households). The most enjoyed activities (very pleasant) were Care and Guidance of children (22 percent of the households), Leisure Time (55 percent), and Social Contacts (50 percent).

- *Importance of the results*

The importance of activity results might interfere with the perceived performance of reduction options and thus influence acceptance. The importance of tasks for the respondent was measured for 11 activity categories on a 5-point ordinal scale 'very important (score 5); important; neutral; not so important; very unimportant (score 1)'.

Cronbach's alpha was 0.75 for these 11 items. The variable Importance was constructed by adding the scores for the items per household (mean 45.3, s.d. 3.8, minimum 28, maximum 55). The items were not weighted.

In general most respondents valued the result of activities as 'important' to very important (80-90 percent of the households). Results most highly valued were for activities relating to the care and guidance of children, scored most often as 'very important' (59 percent). The least valued results involved Large Purchases, which scored mostly 'unimportant' to 'neutral' (38 percent).

- *Experience of having enough time for activities*

The perception of time could influence the acceptance of reduction options. There might be two reasons for this. Firstly, whether enough time is available for activities might influence the time necessary to inquire about, investigate, and adopt a reduction option. Secondly, when time is an important issue and reduction options are expected to require more time once adopted, time influences acceptance as well. Therefore the variable Experience of Time was constructed. It measured how the respondent felt about the amount of time she or he had for the 11 activity categories, on a 5-point ordinal scale (too little [score 1], little, neutral, enough, more than enough time [score 5]).

The reliability analysis had a relatively high Cronbach's alpha (0.89). The variable Experience of Time was constructed by adding the scores of the items per household (mean 38.4, s.d. 6.7, minimum 16, maximum 55). The items were not weighted.

Remarkable was that answers regarding Experience of Time were more divided over the answer categories than were those for the other composed variables about aspects of household organisation. Most households were either neutral or leaning to slightly positive about how much time they had to carry out activities. The highest score was for activities related to Food and to Care and Guidance ('enough time' to 'more than enough time': 79 percent; 77 percent), the lowest score was for Leisure Activities and Social Contacts ('very little time' to 'little time': 31 percent; 28 percent).

- *Home Production*

Home Production was measured by adding three variables to a new one: whether households froze fresh vegetables themselves (no/yes), whether they had an standing order for organically grown vegetables (no/yes), and whether they had their own vegetable garden (no/yes).

- Most households (45 percent) scored 0 and thus carried out none of these home-production activities.
- 42 percent of the households applied one of the activities, of which 85 percent froze fresh vegetables themselves, 8 percent had a standing order for organically grown vegetables, and 7 percent had a vegetable garden.
- Of the 12 percent of the households that applied two home production measures, 75 percent (33 households) had a vegetable garden and froze vegetables themselves, which was not unexpected; 23 percent (ten households) froze vegetables themselves and had a standing order, 2 percent (one household) had both a standing order for organically grown vegetables and a vegetable garden.
- Only four households scored 3 and applied all the home production measures (1 percent).

Eighty-seven percent of the households scored either 0 or 1. This variable could not be seen as a scale for Home Production. The three items were apparently too different and nearly excluded each other, apart from 'vegetable garden' and 'freezing fresh vegetables'. Nevertheless, it was assumed that more home production took place when the scores were higher.

- *Use of commodities*

Use of Commodities was also a newly constructed variable that embodied three others. These concerned whether households had a dishwasher (no/yes) and freeze capacity (no/yes) and whether the household had a dryer (no/yes). These variables were chosen because households varied more in ownership of these appliances than, for instance, the washing machine and the refrigerator. Scores ranged from 0 to 3.

Table 5.40 Ownership of appliances and combinations of ownership (*) (% of households)

Dishwasher	Freeze capacity	Dryer	% of households
-	-	-	4.1
*	-	-	0.3
-	*	-	19.7
-	-	*	3.6
*	*	-	12.1
-	*	*	25.4
*	-	*	1.2
*	*	*	33.3

Most households had two appliances (38.7 percent), followed by those with three (33.3 percent). Nearly a quarter of the households had one appliance besides a washing machine and a refrigerator.

- *Contracted time*

Time left for household management was estimated by asking about the respondent's and partner's work hours, hours used for travelling to work or to study, and hours that were spent on other obligations outdoors, such as clubs, classes, charity, and so on. The more contracted time, the less committed time for household activities was left. Two new variables were constructed: one for the respondent plus partner and one for the respondent. These new variables were related to the acceptance of single reduction options and to acceptance in general.

– The six variables (three for the respondent, three for the partner when applicable) were added (Hours away R + P). Respondent and partner were on average 56.1 hours/week away from home (s.d. 27.5 hours, minimum 0 to maximum 82 percent of the hours in a week).
– A similar variable for the respondent was made (Hours away R). Of the female respondents, 59.1 percent had a paid job. On average, respondents were away from home for 20.5 hours (s.d. 16.6, minimum 0 to maximum 80 hours per week).

- *Use of household help*

Respondents were asked whether the household had domestic help (no/yes). Eleven percent of all the households said they did.

Composed variables and scales about environmental friendliness

In the following, four types of composed variables and scales are examined, which measure Environmental Awareness, to what extent the environment is taken into account in household behaviour (Application), knowledge about energy-sound behaviours (Knowledge) and the extent to which household behaviour was actually energy friendly (Use).

- *Environmental Awareness*

The general attitude towards the environment was measured with a widely used scale to relate attitude to the acceptance of reduction options. The results could be compared with the importance of the relations of household scales to acceptance. The scale is used in the National Monitor of Environmental Behaviour and was thoroughly tested in the past (Couvret and Reuling, 1998). Scores in this sample are as follows:

Table 5.41 Attitude towards the environment in general

Scale item	(totally) Disagree (%)	Neutral (%)	(totally) Agree (%)
The poor state of the environment …			
…is not good for my health	12.1	35.4	52.5
…affects the future of my children	3.2	12.6	84.2
…has consequences for my own life	11.5	27.3	61.2
All this fuss about the environment is exaggerated	71.2	16.4	12.4
I am worried about the condition of the environment	10.5	25.2	64.3
I can see that the state of the environment is becoming increasingly poor	13.1	31.1	55.8

The item most often agreed upon was 'the poor state of the environment affects the future of my children' (84 percent). When the item 'all this fuss…' was recoded into the same direction as the other items, the Cronbach's alpha of the scale that was formed out of the six items was 0.82, and 0.83 when made with standardized items. This result indicated that the scale was suitable to measure environmental awareness[25]. The environmental awareness scale was constructed by adding the scores (totally disagree 1 – totally agree 5) on the items (mean 22.7, s.d. 4.1, minimum 9, maximum 30).

- *Environmentally sound household behaviour scale: Application*

Environmental awareness is a relatively abstract and cognitive concept. To investigate whether households actually took the environment into account, the scale for environmentally sound household behaviour Application was constructed.

Households were asked to what extent they took the environment into account in 12 practices related to reduction options in the survey: for instance, 'to what extent does the environment play a role in…buying flowers for yourself or for others'? Households could answer on a 4-point ordinal scale (no 0/ maybe in future 1/ sometimes 2/ often 3).

[25] National results in 1997 were: Cronbach's α: .90, mean 20.8, minimum 6, maximum 30 (Milieumonitor, 1998)

The 12 practices were pre-rinsing of dishes, heating the house, floor covering, car use, holidays, buying flowers, meat, consumption of pre-frozen vegetables, consumption of fresh vegetables in the winter, dryer use, choice of wash temperatures, and the wearing of clothes.
The scale Application was constructed by adding the scores on 11 items per household. The items were not weighted. Use of a tumble dryer was excluded, as not all households had one. Cronbach's alpha of the 11 items was 0.84 (n=348; with the 'dryer use' item, alpha would be 0.73), which indicates that the items formed an appropriate scale to measure the environmental friendliness of household practices (mean 15.3, s.d. 7.8, minimum 0, maximum 33).

Most households said that for the 12 household practices they 'never' took the environment into account (i.e. the mode is 'never'). The average was a little higher and lay somewhere between 'maybe in the future' and 'sometimes'. One practice with a very high score was the heating of the house. The practice for which the environment was least taken into account was the buying of flowers.

- *Prior knowledge of reduction options*

To check whether acceptance was related to familiarity with reduction options, at the end of the survey respondents were asked whether they had been unfamiliar (0), vaguely familiar (1), or familiar (2) (3-point ordinal scale) with the 31 reduction options before they filled in the questionnaire. Results are listed in Appendix 5C.

An assessment of the items using a reliability analysis gave a relatively high Cronbach's alpha ($\alpha = 0.87$; n=330). The scale was constructed by adding the 31 items. The items were not weighted (mean 49.4, s.d. 9.4, minimum 12, maximum 62).

Households were most familiar with reduction options that related to direct energy. These were: water-saving shower heads, energy-saving light bulbs, heating one degree less, driving less, and more bicycle riding. The lesser known reduction options were: replacing cut flowers with plants and with ecologically grown flowers, and replacing frozen with conserved vegetables. Interesting also were the responses to 'sharing a car through a company' and to 'replace fresh vegetables in the winter with conserved vegetables'. These answers were equally divided over the answer categories, about 33 percent each.

- *Energy friendliness of use*

Use behaviour was inquired about throughout the questionnaire. These behaviours could be more or less energy-friendly or environmentally friendly. For 28 behaviours the scores were recoded to 0 (relatively environmentally unfriendly) or 1 (relatively environmentally friendly) when the variable met a certain condition. These conditions were either under or above the averaged value or involved possession or no possession (see Table 5.42).

Table 5.42 Conditions for recoding use variables into 0/1 variables

Under/above average	Possession or no possession
Wearing days of clothes	Use of solar boiler
Wash temperatures	Use of water-saving shower head
Weight of car	Use of natural floor materials
Kilometres driven	Energy-saving light bulbs
Capacity refrigerator	Shared car through company
Capacity freezer	Shared car with other household
Heating temperatures	Dryer ownership
Buying flowers for others	Freezer ownership
Use of fresh vegetables	Use of green electricity
Use of frozen vegetables	Pre-rinsing cold or warm
Use of meat replacements	Use of tent
Use of chicken	Car ownership*
Use of fish	Filling of the dryer*
Use frequency of dryer	Frequency of holidays*

** Exceptions see text.*

There were three exceptions for car ownership, filling of the dryer, and frequency of holidays; these were not scored for ownership or no ownership, but categories of use were scored. Having no car or a shared car was valued as 1, one or more cars was valued as 0. Not having a dryer or filling it to half full was valued as 1, filling it more than half full was valued as 0, as more laundry in one load actually takes more energy to dry. Not going on holiday or going only once was valued as 1, more than once as 0. For the purpose of simplicity, the destination or the means of transport were not taken into account.

Scores for the 28 behaviours were added to form the variable Use. The Use score could theoretically range from 0 to 28, but in practice it ranged from 4 to 22. The average was 12.2 (±3.2). This variable gave a general and relative impression of the energy friendliness of the household behaviour. Cronbach's alpha for standardised items was 0.64.

- *Willingness to change with regard to 31 reduction options*

A new variable was constructed for Willingness to Change regarding 31 reduction options. Questions could be answered with dichotomous or trichotomous categories or with ratio scales, and were recalculated. For the options with ratio scales, households that scored above the average were scored 1, under the average 0 (see the first column in Table 5.43). For most of the variables, just the no/yes answer was taken (see the second column in Table 5.43). For some variables, the use of the reduction option was taken into account as well, and these households scored a 1 (see the variables in the third column in Table 5.43).

Table 5.43 Conditions for recoding willingness variables into 0/1 variables

Acceptance of under (0)/above (1) average	Acceptance of 'no/maybe' (0) vs. 'yes' (1)	Acceptance and use of 'no/maybe' (0) vs. 'yes' (1) and use included as 'yes' (1)
Longer wearing days	A shared car through company	Solar boiler
Conserved iso fresh veg.	A shared car with other household	Water-saving shower heads
Conserved iso frozen veg.	A lighter car	Natural floor materials
More meat replacements	Driving less kilometres	Energy-saving light bulbs
More chicken	More public transport	Green electricity
More fish	More bicycle/moped	Pre-rinsing with cold water
	Get rid of a car	Using dryer more selectively
Heating less [1)]	Get rid of the dryer	
Lower wash temperatures [2)]	Get rid of the freezer	
	A smaller refrigerator	
	A smaller freezer	
	Buying plants	
	Buying eco-flowers	
	Buying gifts	
	More tent use	
	H. further, longer, fewer	
	Holidays closer to home	

[1)] Heating less: when households indicated that 'none', 'two parts of the day' ***maybe*** *could be heated less, or 'one part of the day' could* ***certainly*** *be heated less, the willingness was coded as 0; higher scores were coded as 1.*

[2)] Lower wash temperatures: coded 0 when willingness to wash 0 or 1 type of laundry at lower temperatures; coded as 1 when 2 types of laundry were indicated.

The 31 recoded willingness answers were added (mean 10.2, s.d. 3.2, minimum 0, maximum 25). This was done without weighting (e.g. for theoretical energy saving), as the focus was only on whether change was possible. Cronbach's alpha for standardised items was 0.54.

5.6.2 Analyses using the composed variables and scales

Relations between the composed variables and scales

Relations between the composed variables and scales were analysed with Kendall's tau. This was done to increase knowledge about the organisational level of the household and about how the organisational concepts relate to environmental aspects of household behaviour. The significant relations between the variables are shown in Table 5.44. Relations to household characteristics (Tables 5.45 and 5.46) were analysed as well.

The composed variables and scales were coded with ascending values. This implies that when, for example, respondents scored high on Pleasure, they scored high on Importance as well (positive correlation). When the correlations were negative it meant that a higher score on one variable correlates with a lower score on the other.

Table 5.44 Relations between the composed variables and scales (Kendall's τ_b, p<.05, n=376) and the number of relations (No.)

	1	2	3	4	5	6	7	8	9	10	11	12	No.
1. Use	.												7
2. Willingness	.09/.16*	.											3
3. Env. Awareness	.12	.11	.										5
4. Application	.17	.16	.29	.									5
5. Knowledge	.18	-	-	.18	.								3
6. Importance	-	-	.10	-	-	.							4
7. Time	-	-	-.12	-	-	.12	.						4
8. Pleasure	-	-	-	-	-	.29	.17	.					2
9. Task division	-	-	-	-	-	-	-	-	.				2
10. Freq. confer	-.16	-	-	-	-	-	-	-	.32	.			4
11. Combining	-.12	-	-	-	-	.10	-	-	-	.10	.		3
12. Commodity use	-.37	-	-	-.13	-	-	-	-	.15*	.19*	-	.	4
13. Home production	-	-	-	-	.11	-	-.09	-	-	-	-	-	2

** Pearson's R p<.05; - n.s.*

In the following, the relations to Willingness, to Use, to the environmental scales, and to the knowledge scale are described. These correlations were significant for p<.01.

- Willingness was significantly related to three other variables. These were the Environmental Awareness scale, Application, and Use. These three variables reflected environmental friendliness in three ways: (1) awareness, (2) what the respondent said regarding for which household behaviour they take the environment into account, and (3) the actual environmental friendliness in household behaviour compared with other households.
- Use was most often (7 times) significantly related to the other variables. Environmental Awareness, Application, and Knowledge were positively correlated with Use. Organisational aspects like Combining, Frequency of Confer and Commodity Use were negatively correlated; with a higher score, the environmental friendliness of actual behaviour was lower. These three household organisation variables had the most direct relation to Use. Other household aspects were related through these three variables or via Environmental Awareness or Knowledge.
- Environmental Awareness and Application were positively related as well. Respondents with a higher general awareness of environmental problems also behaved more environmentally friendly on a practical level. Knowledge was positively related to Use and Application, but not to Environmental Awareness. Thus, knowledge of the reduction

options was positively related to environmentally friendly behaviour on a very practical level.

- Three significant relations were found (besides the relations to Use) between the two environmental scales and the household variables. Environmental awareness was positively related to Importance but negatively to Time. This meant that the more people were aware of environmental problems the more important the result of household tasks was, and the less they felt that they had enough time to perform those household activities. The third relation was negative: the more households said that their behaviour was environmentally friendly (Application), the fewer appliances they had. This confirmed that households reflected their practices relatively well.
- Apparently Importance, Time, Frequency of Confer, and Commodity Use (all related four times) were more determining household organisation variables than were Pleasure or making use of household help (which was not related at all).

Correlation analyses were done to see whether the composed variables and scales were related to household characteristics (see Tables 5.45 and 5.46). A positive relation meant that when the respondent had, for instance, a higher education, the environmental friendliness of Use was higher as well; a negative relation meant that when, for example, the total number of inhabitants was higher, the willingness to change was lower.

Willingness was relatively often related to education, number of inhabitants, and age. Use, Use of Commodities, Frequency of Confer, and Task Division were relatively often related to education, number of inhabitants, and age on the one hand and to work and income on the other. Time was negatively related to work and income as well.

*Table 5.45 Household characteristics plus Use, Willingness, Knowledge, and environmental scales (Kendall's τ_c, n=376; p<.05)**

Household variables	Use	Willingness	Knowledge	Environmental Awareness	Application
Education respondent	0.23	0.08	.15	.10	.11
Education partner	-	-	.12	-	-
Total inhabitants	-0.13	-0.11	-	-	-
No. children at home	-0.09	-0.12	-	-	-
Age of eldest child	-0.09	-0.08	-	-	-
Age of respondent	-	-	.12	-	-
Hours away/week P+ R	-0.13	-	-	-	-
Paid job respondent	-0.16	-	-	-	-
Net income	-0.13	-	-	-	-
Rented/bought house	-0.15	-	-	-	-
Household help	-0.08	-	-	-	-

** Religion was not significantly related; - n.s.*

*Table 5.46 Household characteristics and aspects of household organisation (Kendall's τ_c, n=376)**

Household variables	Commodities	Combining	Confer	Task Division	Time	Pleasure
	p<.03	p<.01	p<.02	p<.01	p<.01	p<.04
Education respondent	.14	-.16	-	.15	-.24	-
Education partner	.	-	.22	.29	-	-
Total inhabitants	.18	-	.14	.13	-	-
No. children at home	.14	-	-	-	-	-
Age of eldest child	-	-	-	-	-	-.11
Age of respondent	.	-.15	-.11	-	-	-.11
Hours away/week P+ R	.18	-	.27	.20	-.16	-
Hours away/week R	-	-	.11	.12	-.26	-
Paid job respondent	.13	-	.14	.21	-.33	-
Net income	.24	-	.24	.28	-.14	-
Rented/bought house	.30	-	.33	.19	-	-
Household help	.10	-	-	-	-.10	-

** Home Production was not significantly related to any of the household characteristics; Importance only to education of the respondent (τ_c= -.11) and religion only to Pleasure (τ_c=.10); - n.s.*

The respondent's level of education and the total number of inhabitants including number of children were relatively often related to aspects of household organisation and the environmental scales. On the other hand, Knowledge, the two environmental scales, and Pleasure were seldom significantly related to household characteristics.

Qualitative comparison of aspects of household organisation

Aspects of household organisation were further analysed to determine whether households valued the tasks differently. Therefore, factor analyses were done for the items Combining, Time, Importance, Pleasure, Task Division, and Frequency of Confer. The Principal Component Analysis (Varimax rotation, missings replaced by means) was used.

Results of the factor analyses of the composed variables are summarised in the following Tables (see also Appendix 5B). First the results for Combining are shown, because these items were different from those of the other composed variables and could not be shown in the same table.

Table 5.47 Factor analyses for Combining

Items of Combining; R^2: 46 %	Factor 1	Factor 2
Cooking with housework	.603	-
Dinner with friends (also friends of children)	-	.484
Cooking/dishwashing with guidance of children	.453	-
Cooking with reading/TV/music	.613	-
Cleaning with laundering	.770	-
Laundering with reading/TV/music	.787	-
Daily shopping with services	-	.430
Daily shopping with transport work/study	-	.784
Transport work/study with transport children	-	.749
Daily shopping with transport children	-	.645

For Combining, after three iterations the analysis resulted in two factors with an eigenvalue >1 (R^2=0.46). The first factor had high scores on activities related to indoor household management. The second factor had high scores regarding social and outdoor activities.

Table 5.48 Summary of the reliability and factor analyses of organisational aspects

Reliability analysis	Confer	Task division	Pleasure	Importance	Time
Cronbach's alpha	.97	.89	.69	.75	.89
Factor analysis					
Explained variation R^2	77% (88%)	62%	51%	55%	60%
Number of factors	1 (3)	2	3	3	2
Results and subscription of activity categories to the different factors					
Food	2	2	2	1	1
House	2	2	2	1	1
Clothing and Shoes	2	2	2	1	1
Daily Shopping	2	2	3	1	1
Care and Guidance	1	2	1	2	1
Work and Study	1	1	1	3	2
Other Activities and Help	1	1	1	2	2
Leisure Activities	1	1	1	2	2
Organising and Planning	-	1	3	3	2
Social Contacts	1	1	1	2	2
Large Purchases	3	1	3	3	2

- For Frequency of Confer, the factor analyses of the ten items (see §5.8) resulted in only one factor with an eigenvalue of >1 (R^2=77 percent; three iterations). This result confirmed that of the reliability analysis. Forcing up to three factors (seven iterations) gave R^2=88 percent.
- It seemed that the activities related to food, house, and clothing nearly always appeared together in one factor (either first or second). For Importance and Time in particular these indoor housework routines explained the most variance (first factors).
- The same was true for Leisure Activities, Other Activities and Help, and Social Contacts. In particular for Frequency of Confer, Task Division, and Pleasure, these leisure and social activities explained the most variance (first factors).
- Organisation and planning and purchase of large items also appeared together in the factors (strategic thinking). Daily Shopping, Work and Study, and Care and Guidance were valued differently. These categories were not related as strongly to any one of the other categories and were clearly judged differently.

It can be said that in general the forced factor analysis showed which of the 11 items correlated more or less to the others, indicating that households had preferences among the activity categories. Because of the high values for Cronbach's alpha, it is probably better to say that, despite the preferences, households had an overall tendency to discuss, divide, or experience activities more or less in one direction.

Although the factor analyses results indicate that it might be useful to divide the household activities into, for instance, indoor and outdoor activities, daily routines and long-term planning, or social and obligatory tasks, the composed aspects of the household organisation were set up and intended to be used as a whole. Reliability analyses showed that that was possible. Another reason to use these variables as intended was that in designing the reduction options and the questionnaire these distinctions were also not taken into account. Nevertheless, the results are taken into account in the final discussion, as they provide important information about household organisation in general and could give additional clues as to how to address behavioural changes in households.

5.6.3 Use behaviour and explaining willingness to change

In the following, the Use and Willingness variables are assessed with regression analyses. This was done to explain the variance in these variables, in order to distinguish determinants that can be taken into account when measures for behavioural change and energy saving are developed.

Regression analyses

For regression analyses, the variables mentioned in Table 5.49 were taken into account.

Table 5.49 List of variables (23) included in regression analyses for Willingness to Change

Aspects of organisation	Environmental scales	Household characteristics
Frequency of Confer	Environmental Awareness	Education respondent
Task Division	Application	Age of respondent
Combining	Knowledge	Paid job respondent (no/yes)
Importance of results	Use[a]	Net income
Pleasure in activities		Hours away P+R
Experienced Time		Hours away respondent
Commodity Use (0-3)		Work hours respondent
Home Production (0-3)		Number of children at home
Household Help (no/yes)		Religion
		Partner living in

Regression analyses could be done, as there was no multi-collinearity; variance in the scores on Willingness, Use, and the independent variables was not zero; the Willingness and Use variables were of interval level and did not have outliers.

To examine whether environmentally friendlier behaviour itself influenced Willingness, Use was included but adapted: a new composed variable Use[a] was constructed using 21 items. The seven items in Table 5.43 (third column) that score 1 on Willingness when these were applied (e.g. the solar boiler) were left out. Including the 7 items both in Willingness and in Use would have meant that the variable Willingness would be explained by items that had been used for its construction.

For Willingness, including all the variables in a regression analysis (Enter method) led to an explained variance of 11 percent (see Appendix 5A). Skipping the variables that had a significance of $p>.05$ resulted in a solution that explained 10 percent with three variables (see Table 5.50).

For Use, two regression analyses were done: once with the same variables as mentioned in Table 5.49, and once without the variable Commodity Use. This variable influenced the score on Use considerably. Households lacking a dishwasher, freezer, or dryer scored logically higher on Use than did those that owned these appliances. Without the variable Commodity Use, the explained variance in the final model was 25 percent; with this variable it was 34 percent (see Appendix 5A and Table 5.50).

For further analyses, households were divided into two groups, following Moore (2000) and his ‘mainstream market’ and ‘early market’ divisions (respectively 84 percent and 16 percent). This was done for both Willingness and Use. The groups were subsequently referred to as the 'top groups' and the 'mainstream groups'. Depending on the cumulative percentages at a certain and discrete score where a split could be made, the mainstream groups in this sample were 83-85 percent. The top groups represented 15-17 percent of the households with the highest scores on Willingness and Use. For these four subgroups, regression analyses with the variables mentioned in Table 5.49 were done again.

The variables shown in Table 5.50 explain in decreasing order the variance in Use and Willingness.

It was analysed as to whether the top and the mainstream group (based on Willingness) differed in Use (ANOVA, means, p:.20); this appeared not to be the case. Within the mainstream group a light correlation between Willingness and Use (P’s R 0.13; p:.03, n=292) existed, which was stronger in the top group (P’s R .33; p:.02, n=52). The relation between Willingness and Use (P’s R 0.16; p:.003, n=344) was significant as well (see Table 5.44).

Also checked was whether the top and the mainstream groups of both Willingness and Use differed in demographic and organisational household characteristics (Appendix 5A, Table 3).

- For Willingness, the top group scored higher on Application, solar boiler possession, freezing, one-pan meals, and Combining. Their familiarity with energy-saving white goods was lower and they conferred less with a partner about the care and guidance of children. The findings indicated that partners' separate routines provided opportunities for unusual change.
- For Use, the top group scored higher on Application, Knowledge, Education of respondent, and Willingness; it scored lower on partner living in the house, Frequency of Confer, net income, more often a rented house, and less hours spent from home by both respondent and partner. Apparently the situation led to more energy-friendly household behaviour, and at the same time to more knowledge and to willingness to behave accordingly.

Table 5.50 Regression for the total sample, the mainstream, and the top groups for Willingness and Use[1]

Willingness (100% households)	R^2 10%	Willingness ≤ 13 (85% households)	R^2 10%	Willingness > 13 (15% households)	R^2 45%[2]
Variables	beta	Variables	beta	Variables	beta
Application	.231	Number of children at home	.237	Combining	.550
Combining	.118	Application	-.134	Use[a]	.348
Number of children at home	-.192	Combining	-.126	Frequency of Confer	-.325
		Age respondent	-.138	Application	.279
Use (100% households)	**R^2 34%**	**Use < 16 (83% households)**	**R^2 22%**	**Use ≥ 16 (17% households)**	**R^2 16%**
Variables	beta	Variables	beta	Variables	beta
Frequency of Confer	-.145	Frequency of Confer	-.227	Knowledge	.419
Application	.114	Use of Commodities	-.255		
Knowledge	.154	Education respondent	.302		
Use of Commodities	-.349	Paid job respondent	-.128		
Education respondent	.265				
Household Help	-.109				

[1]*Enter method, iteratively, excluding least explaining variables by hand; missings: exclude cases pair-wise, shown are adjusted R^2 and standardised beta coefficients; $p < .05$*

[2] *With the unadapted 'Use' instead of Use*[a] *variable R^2 would be 59 percent*

Description of the regression analyses results

Results are described and grouped according to the main findings.

Contrasting R^2s for Willingness and Use

- The explained variance for Willingness with regard to the top group was higher than for the total sample and the mainstream; for Use it was the opposite. This can be explained by the fact that Willingness and the mainstream group's choice of reduction options were per definition arbitrary because the options were not yet being applied. For the whole group and the mainstream group, the low explained variance (10 percent) of Willingness supported this. The top group knew better what they were talking about, which was reflected in the influence of Use[a]. It was therefore not surprising that the explained variance of the Willingness of the top group was relatively high (45 percent).
- However, the largest variation (34 percent) of Use was explained for the whole group. The score on Use was less arbitrary and could consequently be better explained by household organisation variables. The regression solutions for the mainstream and the top group gave less information about what caused the difference in actual energy friendliness of household behaviour within these groups, and gave a lower explained variance.

Link between Willingness and Use

- One clear result was that Willingness of the total sample and of the mainstream group was not explained by Use or Use[a]. This again demonstrates that these are very different concepts. There was just one link between Willingness and Use: for both Willingness and Use of the total sample, Application was included. This scale was a reflection of how households thought that they took the environment into account for certain household behaviours. Use and Application were positively related (τ_c:.17), and Use was a more quantified measurement of the Application scale. This makes the scores on Willingness more reliable and the concept Willingness more accessible, because how households see themselves influences Willingness and is related to the quantified measure Use.

Comments on the regression solutions for Willingness

- Apart from the scale Application, Combining influenced the Willingness of the total sample and the subgroups. Apparently 'doing more things simultaneously'[26] played a role in the willingness to accept more options. Analogous to the relation between Environmental Awareness and Application, Combining might be a practically measured outcome of a more psychological and abstract concept.
- However, for the mainstream and top groups, the variables Combining and Application had opposite effects. It was likely that the mainstream thought they 'already do enough' (1) for the environment (Application) and (2) in general (Combining). It was probable that the

[26] Apparently doing more multi-tasking does not reflect the ability and the ease to carry out more tasks simultaneously; it might simply be necessary to get things done.

opposite effects for the mainstream and top group indicated problems that the mainstream group had to contend with in order to shift to more energy-friendly household behaviour.

- The opposite effect was found for the number of children as well. The influence of the number of children on Willingness was negative in the total sample and positive in the mainstream group. Unlike Combining and Application, which played a role in the total sample as well as in both subgroups, the number of children did not explain variance in the top group. This indicated a curvilinear relation: The number of children had a positive influence in the mainstream, and a negative influence in the top group, although it was not significant, possibly because of an unequal distribution of cases.

Comments on the regression solution for Use

- Variables that explained the variance in the total sample had a similar effect in the subgroups (such as Frequency of Confer, Use of Commodities, Knowledge, and Education of respondent). This again shows that Use is a straightforward concept. Knowledge had a large influence in the top group.
- The Frequency of Confer was negatively related, which was counter-intuitive. The idea was (see §5.8) that more conversation would lead to easier change. It is possible that routines played a more positive role than the need to confer. When discussion was needed to arrange things it might have meant that (1) no time, space, or energy was left to do things in an energy-friendly manner, (2) many things needed to be arranged and the solutions that were found cost energy, and (3) differences between household members exist in their needs and goals.

To determine what caused the counter-intuitive influence of Frequency of Confer and to check for indirect effects, regression analyses were done with eight independent household variables (see Table 5.51; plus 'number of kids at home'). This was also done for three other variables that were important in the regression outcomes of Willingness and Use.

Table 5.51 Regression of four aspects of household organisation ($p<.05$)[1]

	Frequency of Confer R^2 34%; beta	Knowledge R^2 10%; beta	Combining[2] R^2 4%; beta	Application[3] R^2 3%; beta
Net income	.182	-	-	-
Education of respondent	-	.201	-.158	-
Age of respondent	-.139	.174	-.137	-
Hours away P+R	.479	-	-	-
Paid job respondent	-.121	-.234	-	-.362
Hours work respondent	-	.172	-	-
Hours away respondent	-	-	-	.251

[1] Results for the standardised beta coefficients; Enter method, iteratively, excluding least explaining variables by hand; missings: exclude cases pair-wise, shown are adjusted R2 and standardised beta coefficients; $p<.05$, not in explaining order.

[2] For the mainstream group, the same regression solution as for the total sample; education is negatively related to Combining in the mainstream and top group.

[3] A second regression solution (R^2 3%) consists of net income (β -.152) and education respondent (β .173).

Frequency of Confer was positively influenced by the hours that partners were away from home, which was an indication that many household activities needed to be geared to another and divided among the partners. This latter was confirmed by the relatively high relation between Frequency of Confer and Task Division (see Table 5.44). Together with the influences of the other household characteristics, such as net income, Frequency of Confer was probably more an aspect of lifestyle, which could be related to practical circumstances.

Household characteristics did not have a strong indirect influence through the other composed variables (relatively low explained variances) Knowledge, Combining, and Application.

5.7 Further reduction option analyses

Further analyses of the reduction options were done to examine whether groups of reduction options could be found (clustering) and whether considered options were chosen.

5.7.1 Clustering of reduction options

For the reduction options and knowledge of them, factor analyses were done to determine whether clustering was possible. It was felt that clustering of options might lead more easily to measures for energy saving. Analyses were carried for the reduction options in Willingness, Attractiveness, Knowledge, Application, and Use. In addition, bivariate correlation analyses (Pearson's R) were done with the reduction options in Attractiveness.

Willingness and Attractiveness

For willingness to change, two sets of variables were used to distinguish clusters of reduction options.

- The first was the set with which the Willingness variable was composed (described in §5.8.3). Each variable had a 0-1 score.
- The second was the set of 31 options, four of which could be chosen (Attractiveness). Each variable in this set had a 0-1 score as well, but the distribution was different from the first set.

Both sets were used in a factor analysis.

The results were not promising.

- The first set of variables (Willingness) resulted in 12 factors (principal component analysis, varimax rotation, Kaiser normalisation, missings replaced by means, KMO: .374; Bartlett's Test of Sphericity: p:.050; R^2: 70 percent, number of iterations: 28). See Appendix 5D.
- The second set of variables (Attractiveness) resulted in 14 factors (principal component analysis, varimax rotation, Kaiser normalisation, missings replaced by means; KMO: .518; Bartlett's Test of Sphericity: p:. 000; R^2: 59 percent; iterations: 31).

This meant that of the 31 reduction options each factor combined at the most two or three options.

Knowledge

For Knowledge, the set of variables at the end of the questionnaire was used: whether respondents were unfamiliar, a little familiar, or quite familiar with each of the 31 reduction options. After 11 iterations the factor analysis resulted in ten factors, R^2=65 percent (see Appendix 5D) that showed a little more consistency compared with those of Willingness to Change and Attractivess. Factor 1 (flowers, vegetables), 4 (meat, holiday), and 8 (floor covering, lighter cars) had high scores for options that were related to indirect energy. The car-use options were divided over three factors (5, 6, and 8). The other factors combined options that could reasonably be expected in combinations. These were: less capacity in cooling and freezing appliances in factor 2; laundering options in factor 3; replacing the car options in factor 5; car sharing options in factor 6; renewable energy options (solar boiler and green electricity) in factor 7; known but not often applied direct energy options in factor 9 (energy-efficient appliances, pre-rinsing cold, and heating less), and known, often applied direct energy options in factor 10 (energy-saving light bulbs and water-saving shower heads).

Having this number of factors, many with expected and very specific combinations, indicated that knowledge about options was linked to the nature of the options. Appendix 5C shows which options were more or less known.

Application

A factor analysis regarding items in the Application scale (PCA, Varimax, missings replaced with mean) resulted after five iterations in three factors with an eigenvalue >1 (R^2=0.54) (see

Appendix 5D). The first factor had high scores for taking the environment into account for holidays, buying flowers, eating meat, consuming frozen vegetables, eating fresh vegetables in winter, and floor coverings. Regarding how often the environment was taken into account, these practices were mostly rated ‘never’. The practices were related to *indirect* energy use. The second factor had high scores on pre-rinsing dishes, house heating, car use, and wash temperatures, all related to *direct* energy use. Respondents ‘sometimes’ to ‘often’ took the environment into account. The third factor had high scores for the wearing of clothing and use of the dryer, rated with respectively ‘never’, and ‘is not often used’. It was unclear why these two items were in a separate factor. It can be concluded that for indirect energy options the environment was not taken into account, but for direct energy options somewhat more. A different situation was evident with regard to the wearing of clothes and using the dryer.

Use: energy friendliness of 28 behaviours

A factor analysis of the 28 Use items (PCA, Varimax, missings replaced by means) resulted after 12 iterations in 11 factors with an eigenvalue >1 (R^2: .61 percent) (see Appendix 5D). The factors were formed of specific behaviours. The combinations of items that scored high on the second, fourth, fifth, and ninth demonstrated a resemblance to respectively the fifth, second, seventh, and tenth factor of the Knowing items.

Bivariate clustering through correlation analyses

To find clusters for reduction options, a different way was tried: namely, using bivariate correlation analyses. These were done for the second set of variables (Attractiveness). In total, 19 combinations were significantly related (see Table 5.52).

Table 5.52 Reduction option combinations that households were willing to try

Combinations of significantly related reduction options		Pearson's R*	Activity category**
Positively related			
Solar boiler	Shared car (household)	.17	P-T
"	Green electricity	.19	P-H
Shared car (company)	Shared car (household)	.41	T
"	Get rid of car	.18	T
Do not replace the freezer	Drive fewer kilometres	.19	F-T
"	Holidays longer/further/less often	.36	F-L
Do not replace the dryer	Holidays longer/further/less often	.36	F-L
Smaller refrigerator	Smaller freezer	.23	F
"	Pre-rinse dishes cold	.16	F
Heat 1°C less	Lower wash temperatures	.20	H-C
Use dryer more selectively	More bicycle/moped	.19	C-T
Conserved i.s.o. fresh veg.	Conserved i.s.o. pre-frozen vegetables	.31	F
"	Plants i.s.o. cut flowers	.16	F-S
"	Gifts i.s.o. cut flowers	.16	F-S
Gifts i.s.o. cut flowers	Plants i.s.o. cut flowers	.26	S
Negatively related			
Solar boiler	Plants i.s.o. cut flowers	-.15	P-S
"	Gifs i.s.o. cut flowers	-.19	P-S
"	Conserved i.s.o. greenhouse/imported veg.	-.16	P-F
Green electricity	Heat less	-.13	H

** p<.005;*

*** F: food; P: purchases; T: transport; L: leisure; S: social; H: house; C: clothing*

The following can be said about the results in Table 5.52:

- All combinations of the reduction options were technically possible, with the exception of sharing a car through a company and with another household;
- The highest number of significant combinations occurred in the activity categories Food and Transport and Social Activities (i.e. replacements of cut flowers), followed by Large Purchases (solar boiler) and House (green electricity, heating). The lowest number of combinations was for options in the activity categories Leisure Time and Clothing;
- Only for Food and Transport and for cut flowers did reduction options form combinations within the activity category. In other words, most combinations were formed with reduction options in different activity categories.

When Table 5.52 is compared with Table 5.37 the following can be said: The options seemed to form combinations that were 'popular-impersonal' (upper leftmost cell in Table 5.37 for e.g.

conserved food and cut flowers) or 'less popular – personal' which cost effort or offers (e.g. transport and holidays, Table 5.37: middle and right cell in the lower row).

In short: No clear clustering of reduction options was found. Even the combinations of two options were spread over two activity categories, with the exception of the popular conserved food and cut flowers options.

5.7.2 Considerations for change

Households' opinions about the reduction options are shown below. It was examined by means of variance analyses whether the mainstream and top group (for Willingness ≤ 13 and > 13) differed in their opinions. The investigation began with the indirect energy reduction options, for which the number of considerations were restricted (see §5.2.2), followed by the direct energy reduction options.

Indirect energy reduction options

First the results of four indirect reduction options were shown, for which it was asked briefly whether the options would cost less/equal/more money/time/effort or knowledge.

Table 5.53 Replacements of indirect energy options cost less/equal/more money/time/effort/knowledge (%, n=376)

	Natural floor materials cost				Replacements of flowers cost			
	less	equal	more	Total	less	equal	more	Total
Money	4.1	12.7	83.2	100	5.6	74.4	20.0	100
Time	14.0	58.8	27.2	100	3.7	57.9	38.4	100
Effort	12.6	58.0	29.4	100	4.0	52.8	43.2	100
Knowledge	4.7	43.6	51.8	100	3.5	60.9	35.7	100

	Meat replacements cost				Replacements of vegetables cost			
	less	equal	more	Total	less	equal	more	Total
Money	20.3	50.5	29.2	100	64.2	23.9	11.9	100
Time	9.7	73.6	16.7	100	78.6	18.1	3.3	100
Effort	6.2	61.5	32.3	100	72.9	24.0	3.1	100
Knowledge	3.0	49.9	47.2	100	42.5	50.1	7.3	100

In general, households were divided in their opinions about the knowledge needed, whereas the majority was relatively consistent about costs.

- Households found natural floor materials more expensive and thought they needed more knowledge than was necessary regarding synthetic materials.
- On average, households thought that replacing cut flowers would not cost more money but that time, effort, and the need for knowledge would increase slightly.

- Meat replacements were estimated to cost equal amounts of money and time, but slightly more effort and knowledge.
- Replacements of vegetables were estimated to cost less money, time, effort, and knowledge.

The mainstream and top group differed with regard to just two opinions about the reduction options: both for effort. Firstly, the top group had a higher score for 'natural floor materials cost more effort' than did the mainstream group (ANOVA means, F: 5.8; p: .016, n=363). Secondly, the top group had a lower score for 'replacements of flowers costs more effort' (ANOVA, means, F: 7.6; p: .006, n=374).

Direct energy reduction options

The same analyses were done for four direct energy reduction options: energy-saving light bulbs, water-saving shower heads, green electricity, and energy-efficient appliances.

Table 5.54 Reasons to buy or not to buy energy-saving light bulbs (%, n=376)

Reason for buying energy-saving light bulbs?	Reason for			
	Not buying	Not important	Buying	Total
Expensive to buy	38.0	57.2	4.8	100
Saves money during use	-	10.2	89.8	100
Time and effort for information payback time	11.5	84.2	4.3	100
Give other type of light	35.7	61.1	3.2	100
Not suitable for all fittings	61.7	36.7	1.6	100
Household members have an opinion	10.2	71.7	18.1	100
Better for the environment	1.1	9.7	89.2	100

The most important reason not to buy energy-saving light bulbs was that they did not suit all electrical fittings. The most important reasons to buy were saving money during use and concern for the environment.

The top group had a higher average score on 'give other type of light' (ANOVA, means, F:3.5, p:.06; n=372) and thought more often that it was not an important reason to considering buying or not, whereas the mainstream group thought more often that it was a reason not to buy.

Table 5.55 Reasons to buy or not to buy water-saving shower heads (%, n=376)

Reason to buy water-saving shower heads?	Reason for			
	Not buying	Not important	Buying	Total
Expensive to buy	18.8	77.2	4.1	100
Saves money during use	3.0	10.1	89.7	100
Time and effort for information payback time	11.4	83.9	4.6	100
Water flow feels different	25.4	66.1	8.5	100
Design of the head is different	4.1	91.0	4.9	100
Household members have an opinion	9.2	72.3	18.5	100
Better for the environment	-	9.0	91.0	100

The most important reason to buy was that water-saving shower heads save money during use and they are better for the environment. Other reasons were 'no reason for consideration'. However, the top group thought more often than the mainstream group that ‘the design of the head’ and the ‘opinion of other household members’ was a reason to buy (ANOVA, means, respectively F: 3.0, p.08, n=367; F: 3.8, p.05, n=367).

Table 5.56 Reasons to buy or not to buy green electricity (%, n=376)

Reason to buy green electricity?	Reason for			
	Not buying	Not important	Buying	Total
Expensive, higher electricity bills	82.9	16.2	0.9	100
Time and effort for information about costs	36.0	62.2	1.7	100
Green image	4.3	84.6	11.0	100
Initiative of electricity companies	6.4	71.7	22.0	100
Household members have an opinion	7.6	77.7	14.7	100
Better for the environment	1.2	19.1	79.8	100

The most important reason not to buy green electricity was the higher electricity bills; the most important reason to buy was the environment. Other reasons were most often found to be ‘no reason for consideration’. However, the top group thought more often than the mainstream group that the green image, the initiative of electricity companies, and even ‘better for the environment’ were more often reasons to buy. The mainstream group more often scored ‘not important’ (ANOVA, means, respectively F:4.9, p:.03, n=344; F:11.1, p:.001, n=345; F:3.7, p:.04, n=356).

Table 5.57 Reasons to buy and not to buy energy-efficient appliances (%, n=376)

Reason to buy energy-efficient appliances?	Reason for			
	Not buying	Not important	Buying	Total
Expensive to buy	26.1	54.9	19.0	100
Saves money during use	0.6	7.6	91.9	100
Time and effort for information payback time	14.2	76.0	9.8	100
Preferences for brand or type	8.4	58.0	33.6	100
Household members have an opinion	3.1	76.3	20.6	100
Better for the environment	1.4	10.1	88.5	100

Reasons to buy energy-efficient appliances were the economic use and the benefit for the environment. Other reasons were found 'not important' reasons for consideration. Compared with the mainstream, the top group more often thought that costs were a reason not to buy, but the savings during use were more often a reason to buy (ANOVA, means, respectively F:3.7, p:.06, n=356; F:3.1, p:08, n=356).

5.8 Follow-up survey

The follow-up survey repeated the questions about acceptance of 31 reduction options about 6-12 months later. Of the 376 households, 234 (62 percent) returned the questionnaire: 62 percent of the mainstream group and 64 percent of the top group. The questionnaire had four major questions about the 31 reduction options, which were examined in the general survey. First the results of these four questions are shown, then the analyses using these ranges of reduction options. Finally a comparison with the general survey is made.

5.8.1 Results of the follow-up survey

The first question was whether the respondents had thought about changing; the second was whether they had tried; the third was whether they had succeeded. These questions had dichotomous answer categories (no/yes) and are summarised below with 'considered', 'tried', and 'succeeded', respectively. The fourth question gave options to answer whether the reduction options were appropriate for the households' situation (not applicable; had/did already; did not need replacement).

Table 5.58 Thirty-one energy reduction options considered, tried, and succeeded (%, n=234)

	Had or did already	Not considered	Considered	Total*	Tried	Succeeded
Solar boiler?	1.3	72.6	26.1	100	3.8	0.4
Water-saving shower head?	46.6	20.9	32.5	100	15.4	11.1
Natural floor materials?	34.9	39.7	25.4	100	11.2	9.5
Energy-saving light bulbs?	50.4	11.1	38.5	100	25.6	23.9
Sharing car (company)?	2.1	91.8	6.0	100	1.7	0.4
Sharing car (household)?	3.0	87.6	9.4	100	3.4	0.9
Lighter weight car?	10.7	70.5	18.8	100	9.8	6.8
Driving less?	23.9	37.2	38.9	100	37.6	29.1
Energy-efficient appliances?	21.0	39.9	39.1	100	21.5	18.9
Not replacing the dryer?	5.6	82.0	12.4	100	3.9	3.0
Not replacing the freezer?	4.7	84.5	10.8	100	3.9	3.0
Smaller refrigerator?	8.6	71.1	20.3	100	3.4	3.4
Smaller freezer?	8.7	73.2	18.2	100	3.9	2.2
Heat one degree lower?	48.3	13.7	38.0	100	34.2	29.9
Green electricity?	8.2	58.9	32.9	100	6.1	5.2
Pre-rinse the dishes cold?	21.9	48.1	30.0	100	24.9	14.2
Replace flowers -> plants?	29.9	37.6	32.5	100	31.2	30.3
Replace with eco-flowers?	3.0	80.7	16.3	100	9.0	2.6
Replace with gifts?	28.2	31.6	40.2	100	38.0	35.5
More public transport?	12.9	67.8	19.3	100	13.7	7.7
More bicycle riding?	41.2	25.8	33.0	100	32.2	30.0
Getting rid of the car?	5.2	85.3	9.5	100	2.6	0 .4
Replace fresh vegetables?	24.4	44.9	30.8	100	25.2	19.7
Replace frozen vegetables?	22.3	55.4	22.3	100	20.6	15.0
Replace meat?	21.9	57.5	20.6	100	17.6	11.6
Holiday closer to home?	30.3	37.2	32.5	100	25.6	23.9
Less often/further/longer?	18.0	65.7	16.3	100	9.4	7.7
Tent instead of cottage/apt?	28.8	54.5	16.7	100	9.0	8.2
Use the dryer selectively?	37.8	38.2	24.0	100	21.9	21.0
Lower wash temperatures?	66.1	7.7	26.2	100	24.0	20.6
Wear clothing longer?	42.3	32.1	25.6	100	21.8	17.1
Average	22.9	52.5	24.6	100	16.5	13.3

** The 'total' is the sum of 'had/did already', 'not considered', and 'considered'.*

Households that answered this question with 'had/did already' were separated from those that had 'considered', 'tried', and 'succeeded'.

On average, 22.9 percent households were of the opinion that they already applied the reduction options; 52.5 percent did not consider the options and 24.6 percent did. Apart from the options of getting rid of the car, fridge, and freezer, which had very low 'considered' percentages (6-12.4 percent), the other options were considered by 16-40 percent of the households.

- 12 reduction options were tried by 80 percent or more respondents (on average 89.9 percent) who considered driving less, heating 1°C lower, pre-rinsing dishes cold, replacing flowers with plants or gifts, using bicycles more, replacing fresh and frozen vegetables and meat, using the dryer selectively, washing at lower temperatures, and wearing clothing longer. All these options consisted of repeated behaviours. Exceptions were buying eco-flowers and using public transport, which might not be so easily available.
- At least 60 percent (on average 77.1 percent) of the respondents who 'considered' succeeded in applying 12 reduction options. These options were equal to the 'tried' options, but without 'pre-rinsing cold' and 'meat replacements', and with 'energy-saving light bulbs' and 'holidays closer to home'. Thus, (24.6*77.1) = 19 percent of the households succeeded in applying at least 12 options.
- The reduction options, about which 20 percent or more of the households claimed that they 'had/did' these already, are the 14 considered and successfully applied options plus using a water-saving shower head, natural floor materials, energy-efficient appliances, and holidaying in a tent.

The five most successful investments and disinvestments (more than 25 percent of the 'considerers' actually applied the reduction options) were: water-saving shower heads, natural floor materials, a lighter car, energy-efficient appliances, and non-replacement of the freezer.

Comparing the percentages of the successfully applied reduction options (see Table 5.59) with the three willingness categories in Table 5.37, 18 reduction options were downgraded one column to the right, with natural floor materials downgraded two columns; this was likely due to the limited time between the general and follow-up survey, compared with the lifetime of floor materials. Heating was upgraded one column.

Table 5.59 Shifted options[1] when 'Succeeded' is compared with 'Willingness'

Attractiveness	Succeeded >25%	Succeeded 10-25%	Succeeded <10%
> 12.9%	Heating less*[2]	Energy-saving light bulbs*	Green electricity
		Energy-efficient appliances	
		Pre-rinse dishes cold	
		Conserved i.s.o. frozen veg.*	
		Conserved i.s.o. import/gh veg.*	
		Water-saving shower head	
< 12.9 percent		Replace meat	Natural floor materials[3]
		Wash at lower temperatures*	More public transport
		Use textiles longer*	Lighter car
			Eco-flowers
			Not replacing the dryer
			Smaller freezer
			H. longer/further/less
			Tent i.s.o. apartment

[1] Most options are downgraded with 1 column to the right; except heating and natural floor materials

[2] Heating: upgraded 1 column (to the left)! [3] Natural floor materials is downgraded 2 columns

** 6 of the 12 most succeeded options*

Table 5.60 Options for which the Succeeded percentage in the follow-up survey was in the same category as Willingness in the general survey

Attractiveness	Succeeded >25%	Succeeded 10-25%	Succeeded <10%
> 12.9%	Plants instead of flowers*	Use dryer more selectively*	Solar boiler
	Gifts instead of flowers*		
< 12.9%	Drive less*	Holidays closer to home*	Shared car (company)
	More use bicycles*		Shared car (households)
			Get rid of the car
			Not replace the freezer
			Smaller refrigerator

** Six of the 12 options most successfully applied*

Thus, of the 12 options most successfully applied, six shifted a column and six did not. The repeated behaviours scored higher than those that acquired investments or involved getting rid of. Exceptions were eco-flowers, public transport, and green electricity, for which restricted accessibility might have played a role.

5.8.2 The considered, tried, and successfully applied options

In this subsection, the 31 options for 'considered', 'tried', 'succeeded', and 'had/did already' (each option with a 0/1 score) are added to construct new aggregated variables: Considered, Tried, New Use, and Old Use, respectively. These variables are used in the next section for further analyses and comparison with the general survey. Further, for the four ranges of reduction options it is investigated whether clusters of reduction options can be found.

Considered

The reliability analysis involving the 31 answers about whether households had thought about change gave a good result: Cronbach's α:.83 (standardized, n=221). The 31 answers were added to form a new variable. This variable could in theory have a value ranging from 0 to 31: '0' meant that 100 percent of the households answered 'no, I have not thought about this reduction option' for all 31 options; '31' meant that they had thought about all 31 reduction options. The average value was 7.9 (s.d. 5.4, minimum 0, maximum 24), which meant that on average less than one third of the options were considered.

The factor analysis involving the 31 items resulted in 10 factors (Varimax rotation, R^2=.59, 22 iterations, n=234, missings excluded list-wise).

Tried

The Tried variable was constructed in a similar manner. The reliability analysis of the 31 answers about whether households tried reduction options (see the column 'Tried' in Table 5.58) resulted in Cronbach's α:.79 (standardized, n=221). When the 31 items were added to form a new variable, the mean value was 5.4 (s.d. 4.4, minimum 0, maximum 19).

The factor analysis involving the 31 items resulted in 12 factors (Varimax rotation, R^2=.63, 12 iterations, n=234, missings replaced list-wise).

New Use

The New Use variable was constructed in a similar manner. The 31 variables used were the 'succeeded' variables, see Table 5.58, last column. The reliability analysis of the 31 answers about whether households succeeded in changing resulted in Cronbach's α :.77 (standardized, n=220). When the 31 items were added, the mean value of the new variable New Use was 4.4 (s.d. 3.9, minimum 0, maximum 17).

The factor analysis involving the 31 items resulted in 11 factors (Varimax rotation, R^2=.59, 21 iterations, n=234, missings replaced list wise).

Old Use

Again, in a similar way the Old Use variable was constructed with the 'had/did already' variables for the 31 options. The reliability analysis of the 31 answers about whether households 'had/did already' resulted in Cronbach's α :.78 (standardized, n=220). When the 31 items were added, the mean value of the new variable Old Use was 7.5 (s.d. 4.7, minimum 0, maximum 21).

The factor analysis with the 31 items resulted in 12 factors (Varimax rotation, R^2=.65, 10 iterations, n=234, missings replaced list-wise).

Conclusions for clustering

As with the ranges of reduction options in the general survey, no clear clustering could be found for the already used, considered, tried, and successfully applied reduction options, since for 31 options the number of factors ranged between 10 and 12. The variables Old Use and New Use are used in the following section.

5.8.3 Analyses of the reduction option applications

In this subsection, it is analysed whether the score involving particular newly applied options can be explained using household organisational aspects. It is done using regression and correlation analyses.

Regression analyses

For the analyses, another new variable was made by combining Old Use and New Use into All Use (mean 11.9, s.d. 3.9, minimum 0, maximum 23).

For three variables (Old Use, New Use, All Use), regression analyses were done with the same set of variables used for the regression analyses in §5.6.3 for Willingness and Use (see Table 5.49). This time Willingness was also included, as the willingness of half a year ago, measured in the general survey, might have influenced the actual change as reported in the follow-up survey. Following the same idea as for Willingness, Use was included as well: Being more energy-friendly might have led to more willingness and to more actual change in the follow-up survey.

*Table 5.61 Regression for Old Use, New Use, and All Use**

Old Use (n=233)	R^2:10%	New Use (n=233)	R^2:11%	All Use (n=233)	R^2:25%
Variables	Beta	Variables	Beta	Variables**	Beta
Knowledge	.182	Commodity Use	.222	Application	.316
Application	.149	Willingness	.175	Willingness	.289
Importance	.154	Age respondent	-.151	Paid job respondent	-.140
Age respondent	.128	Application	.130	Commodity Use	.151
				Religion	.120

**Stepwise regression, missings replaced by means, shown are adjusted R^2 and standardised beta coefficients, p<.05, in decreasing explaining order; ** For the mainstream group (n=197) the same variables emerged in the regression analysis (R^2:24%)*

Application appeared in three regression solutions:

- Application was part of all three regression solutions and was an important variable for Willingness and Use as well.

Willingness, Commodity Use, and Age of the respondent appeared in two regression solutions:

- In New Use and All Use, Willingness was indeed an explaining factor.
- Commodity Use was also part of the solution of New Use and All Use. It was part of the solution for Use as well.
- The role of the respondent's age was not clear. Why would older respondents behave in a more environmentally friendly (Old Use) manner and apply fewer new reduction options (New Use)? Age was negatively related in the Willingness of the mainstream group as well, as is shown in Table 5.50.

Old Use:

- The Importance of the household tasks in Old Use probably showed that Old Use was a combination of a mental construction involving what was important and how households perceived the environmental friendliness of their behaviour regarding the options, and what was actually done. This was because Use was not significantly related to or influenced by Importance, whereas Use was related to Old Use (P's R: .21, p:.002).
- Knowledge was the first explaining variable. Apparently Knowledge influences the perception of Old Use. Knowledge was part of the solution for Use as well.

All Use:

- All Use was negatively influenced when the respondent had a paid job, as was the Use of the mainstream group (see Table 5.50).
- The sum of Old and New Use of reduction options was higher when households were more religious.

Further analyses using Old Use and New Use

The variable Old Use was positively related to Use (Pearson's R:.18; p:.001, n=233).

The variable New Use was positively related to Willingness (Pearson's R: .22; p:.001, n=233) and to Commodity Use (P's R: .21, p:. 002, n=233). The age of the respondent and the eldest child were negatively related to New Use (P's R: -.195; -.145, p<.03, n=233). When the respondent was a woman, the score for New Use was higher (P's R:.17, p=.10, n=233). The score for New Use was also higher when the respondent enjoyed the questionnaire (P's R: .24, p=.000, n=233).

Households that were part of the mainstream group (Willingness ≤ 13, see Table 5.50) applied on average a lower number of new reduction options (New Use on average 4.0), compared with households that were part of the top group (Willingness > .13; New Use on average 6.3) (ANOVA, means, F: 9.96; p.002, n=233).

5.9 Conclusions and discussion

This chapter's structure is adhered to in order to describe the conclusions. Firstly, conclusions about the acceptance of single reduction options at a functional level are described; secondly, conclusions about the aggregated acceptance of options at the organisational level is given; thirdly, comments on clustering and considerations for change are made; fourthly, results of the follow-up survey are compared with those of the general survey; fifthly, comments on the application and development of household theory are made. Finally, new questions and the consequences for energy policies on behavioural change are discussed.

Acceptance of single reduction options at the functional level

The second research question dealt with the acceptance of single reduction options at the functional level: *a. 'How are practices and willingness to accept single reduction options related?'*

When analysing the acceptance of reduction options in relation to the use behaviour, it became clear that four types of relations were possible: more willingness was related to more, less, or a different kind of use or no relation existed at all. The relations undoubtedly would depend on the operationalisation and choice of the behaviour variables. Behavioural variables and willingness were related for nearly two-thirds of the reduction options. Promising energy-saving options were those that were popular and for which more use (higher energy unfriendliness) was related to more willingness. It transpired that these options were repeated behaviours; about one-third of the range of investigated options. Not replacing or getting rid of an appliance or car was much more unpopular compared with changing or reducing the use of it.

Investigating the behaviour and willingness to change at the functional level with this relatively precise method revealed options with high energy-saving potentials. As far as is known, this way of working has not been previously applied. It provides an insight into the more general picture of what kind of behaviours are suitable for change and it helps to choose the kinds of behaviour at which policy strategies should aim.

The popular repeated options that were related to a higher use were: pre-rinsing with cold water (in households that had no dish washer), using the dryer more selectively, heating less during the day when nobody is home and at night, replacing flowers with plants and gifts, and replacing pre-frozen vegetables with conserved vegetables in households that used pre-frozen vegetables and stored them in the freezer as well. Energy-saving light bulbs were also popular. Extra attention is needed in particular for households that do not have energy-saving light bulbs at all, as they are less willing than are households that already use them.

Relation between practices and willingness on aggregated level and determinants

Questions at the functional level were used to form the aggregated variables Use, Willingness, and Attractiveness. The first reflected the environmental friendliness of household behaviour, the second was a composed general attitude variable, and the third was a measurement of general intention to change. Composed scales were also made for aspects of household organisation. Relations between the aggregated variables were analysed using correlation analyses; the variation in Use and Willingness was assessed using regression analyses. Use and Willingness were analysed for the total sample, the top group, and the mainstream group.

With these variables, the two research questions were answered:

(2) *c. What is the relation between practices and willingness to accept energy reduction options, when extended to an aggregated level?, and*
(3) *a. How are characteristics of household management on an organisational level related to practices and the willingness to accept reduction options?*

It was found that a weak relation existed between Willingness and Use in the mainstream group and that there was a relatively strong relation in the top group.

It was concluded that behavioural change was influenced (or hampered) most by the respondents' perception of to what extent they had already taken the environment into account in household tasks (Application); by time constraints and solutions reflected in Frequency of Confer and the number of combined activities (Combining); by number of children, by age, education of the respondent; and by the aggregated knowledge of 31 reduction options (Knowledge).

Three variables had opposite influences in the top and mainstream group. Application had opposite influences in the top group (positive) and the mainstream group (negative) on Willingness to change. A similar opposite influence for Willingness was found for Combining, whereas the number of children had, up to a certain point, a positive influence on the mainstream group but a negative overall influence. This raises the question of which reduction options were either positively or negatively linked to the number of children, household size, or being a one-parent family. Households did not appear to be aware of how the number of children influences the willingness to change. It is likely that the combination with Combining would offer new directions for the development of reduction options. To influence the mainstream group to adopt more options, several initiatives are possible. These could include helping households regarding the number of combined tasks, the influence of children, and their perception of the environmental friendliness of their practices.

The energy friendliness of behaviour was negatively influenced by time constraints and how these were solved, which was visible in the Frequency of Confer, Use of Commodities, and Household Help. In particular, Frequency of Confer was related to Task Division and to the hours that the partner and the respondent were away from home for work, travelling, and other obligations. However, education and knowledge had a positive influence on the energy friendliness of household behaviour. It was clear that considerable environmental benefit could be gained if the household manager's valuation of the environmental friendliness of household behaviour (in the mainstream group) were adjusted. Increasing Knowledge had a positive effect on the energy friendliness of behaviour, but mainly for the top group. If the aim is to change household behaviour, practical problems, time constraints, the solutions that are used, knowledge and valuation of the environmental friendliness have to be taken into account.

How to solve time problems in households is not really a matter for energy policy, but time constraints and the way they are handled definitely influence the energy consumption of a household. Coaching of the household as a whole, to build up new but energy-friendly routines might help. The influence of the number of children and age requires more research, as the reasons for the influence were not quite clear, let alone how interventions would profit from this knowledge. The positive effect of the number of children for the mainstream group might have been due to altruistic reasons; being used to being flexible or making concessions; a positive awareness of responsibility; or to a more structured, regular life in which more change was possible, but only up to a point because the effect for the total sample was negative.
In the mainstream group, with regard to Willingness the negative influence of age and its positive relation to Knowledge lead to the hypothesis that older households and respondents are less willing to change. Perhaps they are influenced by an overly positive perception of the environmental friendliness of their behaviour and feel that no change is needed or desirable. Over time they have gained a general knowledge about reduction options but do not necessarily apply them (no influence of Age in Use). Combining activities (Combining) seemed another solution for time constraints. However, results (a higher score on Combining was related to lower age and education; a higher score on the importance of household tasks and a lower score on Willingness in the mainstream group) indicated that with a higher score for Combining, the household's standards or results were not actually higher; these results might reflect a feeling of pressure or an awareness that tasks were combined (which could be related to forming routines). However, the results indicated that these household managers carried out more tasks themselves rather than outsourcing or reducing them by using other solutions; perhaps even the number of activities was higher. Increasing the number of combined activities would thus have a limit or at least decrease the interest in having more things to think about or to do or to change simultaneously, in particular in the mainstream group.

The following can be said with regard to the accuracy of the Willingness and Use measurements, the relation between these concepts, whether the theories of Rogers and Moore could be used, and whether the conclusions were credible:

- Willingness was explained for 10 percent; Use for 34 percent. This implied that Use was measured well compared with the other measured household aspects. However, Willingness was not necessarily not measured well. It implied that respondents were relatively arbitrary in their choices, which became visible in the higher explained variance for the top group compared with the mainstream group: as the latter make less well grounded choices when they cannot compare with an ‘early market’ (Rogers, 1995; Moore, 2000);
- For Willingness there was an opposite effect for Application, Combining, and the number of children in the mainstream and top group and the total sample. Opposite effects did not exist in the regression solutions for Use, which showed again that Use was a relatively

straightforward concept. The opposite effects for the concepts in Willingness showed the practical challenges faced by the mainstream group in accepting more reduction options upon which interventions could focus.
- The link between Willingness and Use consisted of Application: how households judge the environmental friendliness of their behaviour, which confirmed the other relations between Willingness and Use and made the scores on Willingness more reliable because Use was measured in a more quantified way.

The relation between Willingness and Use thus has several aspects which can be explained using the theories of Rogers and Moore and could be helpful to formulate interventions. It was expected (§5.2.2) that the 'Willing' top group was more energy-friendly than the mainstream group. However, this appeared not to be the case. It was also expected that there was no relation between Willingness and Use in the mainstream group. It was found however, that a weak relation existed between Willingness and Use in the mainstream group and a relatively strong relation in the top group. This confirmed that it would be useful to develop policy strategies on households, because Willingness and Use are definitely related and improvements could be made by means of coaching with simple energy-friendly routines, taking into account Application, Knowledge, organisational aspects, and a top and mainstream group.

Considerations and clustering

Advantages and disadvantages of the changes were investigated by means of the 'considerations'. In general, households were divided in their opinions about the knowledge required for direct and indirect energy reduction options, whereas the majority was relatively consistent in its opinion about the costs.
- For indirect energy reduction options, the top and mainstream group (distinguished for Willingness) differed only in their estimation of what needed more effort (top group: natural floor materials; mainstream: replacing cut flowers).
- For the direct energy reduction options, it could be concluded that the top group was more in favour of use, image, and design aspects than was the mainstream group. These aspects were, for example, another type of light and the design of water-saving shower heads and other family members' opinions about them. Their score was more neutral or they thought these aspects were more a reason to buy than did the mainstream group.

The difference in evaluation in effort and time needed to acquire knowledge (not an important reason for direct energy options) and the evaluation whether more or less knowledge was needed (respondents were divided with regard to indirect options) was probably not inconsistent. Households have other priorities when buying products and when for direct options the time and effort needed to acquire knowledge is not an important reason (because in general it was not taken into account) it can be expected that this will be the case for indirect options as well. Nevertheless, the variation in knowledge influences the environmental friendliness of household behaviour.

The acceptance of the ranges of single reduction options was assessed with factor analyses, to find clusters of options that could be approached simultaneously. The results were that reduction options could not be clustered. The few combinations that were formed were 'popular-impersonal' and spread over the activity categories, with the exception of the popular conserved food and cut flower options.

Possible explanations for the absence of clustering, with the exception of food and cut flowers, are:

- For indirect reduction options, it was found that they were less known, therefore the environment played a lesser role and the expectation varied as to how much knowledge was needed to apply these options. This lack of familiarity would possibly lead to a more random choice of reduction options, which explains why no clustering was found. However, Knowledge did not play a role in Willingness and clustering *was* found for food and cut flowers (indirect options). This indicated that the lack of knowledge was not the reason (or not the only one) for the absence of clustering;
- The mainstream group chose more randomly, partly because lack of knowledge played a role (visible in the regression analyses of Use) and partly because the evaluation of option attributes was different. These two reasons could indicate that the mainstream group had a less distinct opinion in terms of vision and experience;
- Not excluding the above explanation, Willingness and Use were related (although low) in two-thirds of the options, which indicated that household managers could imagine to some extent what the consequences of reduction options were. By definition, respondents would have chosen the reduction options in which they at least saw some advantages for their household situation or which they liked best. According to the Mental Accounting theory, experiencing advantages is more pleasurable when spread over activity categories; such a spread was found, and the options in the found combinations also stemmed from different activity categories;
- Thaler (2000) describes how the Mental Accounting theory works for a small number of losses (integration). However, with 'ranges of losses judged in advance' people become more sensitive to the subsequent losses and therefore at least temporal spreading occurs: hence, another reason why no clustering was found in the study;
- Popular food and flower options were clustered, which was contradictory to the Mental Accounting theory. This exception can be explained by the fact that either the options were not specific enough to apply to different household situations and were thus more or less suitable for all households, or they held other negative attributes but were nevertheless chosen because of the relatively low sacrifices or relative ease of execution. This makes it doubtful as to whether these popular options would actually be carried out. Further exploration of the general survey data on the topic of replacement of vegetables revealed a number of obstructions to do with the consumption of more conserved vegetables. These included a lower appreciation of how they taste, the notion that fresh vegetables were highly energy friendly, and that conserved vegetables were less healthy. This demonstrated the lack of knowledge about the advantages of conserved vegetables (Razenberg, 2000).

Although no exclusive explanation was found, on the basis of the above findings an understanding of the acceptance and non-acceptance of ranges of reduction options increases, and two general theoretical comments on behavioural change can be made. Firstly, when options are not popular, in general it can be assumed with more certainty that these are carried out by households that see an advantage in applying them. This is because the choice is different: choosing because of low costs or advantages that are situation dependent. Secondly, the theory of Mental Accounting takes into account one or two attributes, such as money (Thaler, 2000; Kahneman and Tversky, 2000) or effort (Antonides, 1996), implying that an overall evaluation of a change is positive or negative. However, reduction options include several changes and can simultaneously contain costs, losses, and advantages. The evaluation can be different for different groups of respondents. This was visible in the differences in the consideration of attributes between the mainstream and top group and in the influence of Age in Willingness. Different kinds of evaluations were described in Kahneman and Tversky (2000)[27]. It can be concluded from the above that the Mental Accounting theory should include several evaluation processes that relate to the multi-attributes of different kinds of changes for different groups and that include temporal effects.

With these conclusions and discussion, the third research question (‘*Is it possible to form a typology of clusters of reduction options?*’) is answered: namely, it is not possible, for several reasons.

Comparison of the general and follow-up survey results

The follow-up survey was intended to demonstrate some of the dynamics in behaviour by validating a year later what had happened with the reduction options proposed in the general survey. This was done by comparing which options were popular in the general survey and which were adopted, and by comparing the regression analyses results of Willingness and New Use.

Because of their high popularity and energy-saving potential, 14 options in the general survey were most promising, and nine of them were the most applied in the follow-up survey as well. These were repeated behaviours (see Table 5.62). Of the 24.6 percent households that considered options, eventually (24.6 * 0.77) 19 percent actually changed behaviours, according to their own perception.

Table 5.62 General and follow-up surveys: most applied options

1. Energy-saving light bulbs	6. Holidays closer to home
2. Heat 1ºC less	7. Selective use of tumble dryer
3. Gifts and plants iso cut flowers	8. Wash at lower temperatures
4. Conserved iso frozen, imported, greenhouse vegetables	9. Use textiles longer
5. Driving less; more use of bicycles and mopeds	

[27] Desirability of gains, risk seeking; reduced gains, lowest costs, uncompensated losses, risk and loss aversion; experience vs. decision values, isolation effects, status quo effect, reference effects, time effects, endowment effect, certainty effect, sensitivity effect, variety-seeking behaviour

The five most popular investments (applied by on average 12 percent of the respondents) were: water-saving shower heads, natural floor materials, a lighter car, energy-efficient appliances, and not replacing the freezer.

In fact, most of the options that were related to investments and disinvestments were dropped. These options were: getting rid of something, smaller capacity, and requiring more time, money, or effort in use or to acquire. A small number of repeated behaviours were also not adopted. Either these options were already being applied relatively often (cold pre-rinsing), influenced relatively strongly by the family situation (meat), or the disadvantages weighed heavily (public transport, eco-flowers).

In analyses of Old Use, New Use, and All Use (follow-up survey), most of the explaining variables were found for Willingness and Use as well (general survey). The only two new variables compared with Willingness and Use were 'Importance' in Old Use and 'Religion' in All Use. As with Willingness, the variance in New Use was explained by about 11 percent, which implies that the results of the general and follow-up survey were comparable. Willingness—which can be seen as a form of intention—was an explaining factor of New Use. This was interesting, as it confirmed that intention indeed influenced actual behavioural change and confirmed the findings of the general survey. Compared with the analyses of Use and Willingness, the analyses of Old Use and New Use gave extra information on the importance of how people see themselves and judge their behaviour and behavioural change, although it is not necessarily consistent with actual behaviour and change. Use and Old Use were positively correlated but not highly, and the regression analyses for Use gave a better result (R^2: 34 percent) than for Old Use (R^2: 10 percent). Although there was a positive correlation, many households gave themselves a score that was different from how environmentally friendly they actually were, according to the 0/1 scores for Use. This explained why Importance and Religion were part of the regression solutions for Old Use and All Use and not of Use. The findings also showed that the definition of environmentally friendly behaviour needs to be clear to all parties and needs to be evaluated at the functional level. Otherwise, it will be difficult to convince households that they need to change their behaviour and by how much.

The positive results of acceptance in the follow-up survey might have been influenced by the fact that households that enjoyed the questionnaire, and also had available time, participated in the follow-up survey. This made it likely that they actually applied some of the reduction options and it explained the unexpectedly high percentages of acceptance. Thus, even when New Use was judged over-positively, apparently at least some change was established.

The results were comparable with those in other literature sources. In particular, the results for vegetables and holidays closer to home were comparable with results in the Perspective Follow-up (Novem, 2000). Meat replacements, popular in the general survey and in the Perspective Follow-up, did not do so well in the follow-up survey.

Measuring levels and using other theories

Measuring on a functional level is helpful: firstly, in distinguishing on what types of behaviour energy policy strategies should focus, and secondly, to calculate the reduction potential. Differences in the results between the general and follow-up survey showed the usefulness of aggregating behavioural data compared with asking about behavioural motives, as the latter were explained by perceptions, such as religion and the importance of household management results. The energy friendliness of behaviour was explained by aspects of household organisation and solutions for time constraints. In particular 'work' is a dimension that is normally used[28] to distinguish households. This research shows that this usual manner of distinguishing households can be refined by looking at household organisation aspects (Frequency of confer, Use of Commodities, Household Help, Combining, Importance). The measurement of household organisation aspects was a first attempt and could be extended and improved upon to increase knowledge about how households function. Factors[29] found in this research are likely to apply to other important household-related fields as well, such as budgeting and healthy lifestyles.

To create a relatively homogenous sample, and in particular to reveal obstructions to change, it was chosen to investigate households with children because these households have to deal with many demands and constraints, which were clearly in evidence. However, it turned out that the number of children as well as the age of the respondent, assumed to be relatively homogenous in this sample, had a direct influence on willingness to change.

Using the Mental Accounting theory led to the concept of Pleasure and it was used to explain the findings on clustering. Applying the theories of Roger and Moore led to specific analyses, which led to valuable results in understanding which aspects influence the energy friendliness of behaviour (Use), the intention to change (Willingness to Change), and the perception of actual change (New Use).

Energy policy strategies on behavioural change; further research

What are the implications for energy policy strategies on behavioural change when the results show that changes mainly concern repeated behaviours and an exaggerated positive estimation of one's behaviour?

Because the energy friendliness of behaviour, the intention to change, and the actual change were related, can be assumed that strategies would not be wasted. When strategies focus on knowledge and on practical problems, a certain group of households will then do what they claim they are willing to. There is certainly a group of households that are actually keen to

[28] The other dimension is how household activities are technically and economically interwoven with the household's environment, see section 5.2.1.

[29] Time constraints and household organisational solutions; perception of one's behaviour compared with actual behaviour; role of age and number of children; the role of knowledge and education; and the differences between the mainstream and top group.

contribute to energy saving. The fact that households that enjoyed the questionnaire participated more in the follow-up survey and had a higher number of actual changes (New Use) confirms this.

Strategies for the mainstream group in particular could build on three foundations:

(1) Extend knowledge about reduction options;

(2) Coach on time constraints, with energy-friendly solutions and routines: for example by avoiding complexity and the need to combine activities; by organising travel, work, and commitments differently; and by drawing up household task routines for other household members;

(3) Adjust the perception and the valuation of the environmental friendliness of one's behaviour.

The knowledge and perception adjustment strategies should distinguish for direct and indirect options. It is likely that people's wish for a better world (religion, altruism) and the importance of the results of household management (Importance) can be used: good housekeeping on a global scale. The age of household members and the number of children have to be taken into account as well, but the precise nature of the effects on willingness to change and the energy friendliness of household behaviour is not yet clear and needs further investigation. Indications exist that there are three levels on which to address the household: the household manager, the household as a group and their interaction, and possibly the household in relation to the infrastructure of their surroundings. These influence levels appear to be suitable for different kinds of reduction options, but this certainly needs further investigation. The way that investments can be stimulated in households in a 'status quo' situation, in particular in the mainstream group, also requires more investigation.

Data from the surveys can be used to further analyse the precise considerations and other determinants for the acceptance of each reduction option. The top and mainstream groups differ in opinions about the reduction options. This indicates the problems that the mainstream market faces with regard to single reduction options, in particular for the mainstream group's investment and disinvestment behaviours. For the mainstream and top group, data from the general and follow-up survey can be split for investments and disinvestments as well as for repeated behaviours.

The data is also suitable to estimate the energy-saving potential of the 12 most frequently applied repeated behaviours and the five most applied investments.

6. Conclusions and Discussion

6.1 Introduction

The influence of household management on the acceptance of energy-saving reduction options is investigated in this thesis. The reason is because earlier research has indicated that although people were willing to save energy and to care for the environment, changes in energy-consuming behaviour are limited.

From the household science perspective, a possible explanation for this phenomenon lies in how household management is undertaken. The manner in which people carry out household activities at the functional level determines the energy consumption as well as the space for potential change and reduction of energy. Therefore it is logical to search at the functional level for factors that might advance the reduction of energy consumption. In addition, the way households and their activities are organised and structured will affect practices at the functional level as well as the willingness to change. For example, three factors that can influence a household's energy-saving potential household are the task division between partners, their work and income arrangements, and their organising habits.

Thus, the overall research question addressed by this thesis is:

(O) *What is the influence of household management on the acceptance and energy-saving potential of greenhouse gas reduction options*?

The term household management was chosen above housekeeping because a distinction needed to be made between tasks performed within a household (housekeeping) and the way these tasks are performed *and* organised.

Earlier research on factors that influence behaviour often focused on the individual consumer from a social-psychological perspective, and assumed that the intention to change would lead to behaviour modification. In this thesis, that assumption is abandoned. Instead, the relation between practices and their organisation (actual behaviour), willingness to accept, and the behavioural change after a year are assessed. By using the household science perspective, both functional and structural factors of actual behaviour, willingness to accept, and eventual change can be found.

To answer the overall research question, data were collected in four phases: Firstly, a pre-survey was conducted to find relevant topics for use in a case study to describe textile care; secondly, a case study about textile care was carried out; thirdly, for the general survey a questionnaire was distributed among 376 households to measure the actual behaviour relating to 31 reduction options and to determine whether people would be willing to accept these options in the future. Finally, a follow-up survey was held a year later to assess self-reported change. The same respondents were asked whether in the meantime they had thought about and tried to implement the reduction options and whether they had succeeded. With all these data, it would possible to estimate the reduction potential within households, as well as to determine the functional and organisational factors that influenced this. Furthermore, with this set up it would be possible to locate clusters in respondents' choices of reduction options.

In this chapter, first the conclusions are summarised by answering the research questions. Then the conclusions are discussed and a reflection is given on the methodology and the theoretical relevance. Implications for environmental policy and interventions are described and suggestions for further research are given.

6.2 Selection of reduction options and the energy reduction potential

In the Lifestyle and GreenHouse Projects, the direct and indirect energy requirements associated with consumer expenditures were determined using a hybrid analysis method. The total energy requirement of households consists of 54% indirect energy, and represents up to 70% of the total energy requirement of the Netherlands.

The following research question is addressed in Chapter 2 of this thesis:

(1) *Taking into account the compatibility between reduction options, which technological and economically feasible reduction options for households are available for both direct and indirect energy requirements?*

Results of the projects showed that differences in energy requirements between households existed in the activity categories Recreation, Food, Household Durables and Commodities, Transport, Electricity, Heating (gas), and Clothing. These categories were used to locate reduction options.

It was decided to concentrate on activities within these categories. Examining activities ensures that both practices, for which direct energy is used, and the use of products that embody indirect energy, can be addressed. The way practices are executed influences indirect energy requirements and vice versa. For example, people might do their grocery shopping by car, which costs direct energy. When they buy frozen goods, direct energy is used for storage in their freezer, but also indirect energy because the products were frozen beforehand. By investigating activities, direct and indirect energy requirements and their interaction can be taken into account simultaneously.

Selection criteria of reduction options within these activities were that the reduction potential was at least 0.5 GigaJoule per household, per year, per option, and the total set of options had to be divided over practices on the one hand and investments and purchases on the other. Options also had to be readily available for households.

The selected reduction options are summarised in Table 6.1, and are related to nearly 75% of the total average household consumption. The total economic-technical saving potential was 17% of the total average household energy requirement. This did not include the solar boiler, 'not owning a car', a smaller washing machine, a gas-fired dryer, and less frequent use of the tumble dryer, as they interfered with some of the other options[30]. Including these options and taking into account the effects on other options, the reduction potential was estimated to be 26% (63 GJ).

Table 6.1 Categories of reduction options investigated

	Use/activities/practices	Investments/purchases
Direct energy requirement	Space heating*	Energy-saving light bulbs
	Car use*	Solar boiler
	Wash temperature	Green electricity
	Use of washing machine/dryer*	Water-saving shower heads
	Pre-rinsing dishes	Alternatives for appliances*
Indirect energy requirement	Holidays*	Floor covering*
	Use of textiles	Alternatives for flowers*
	Textile materials*	Meat (substitution, vegetarian)*
		Vegetables*

** these categories of options consist of more than one option*

It was estimated that at least one-fifth to one-quarter of the total energy requirement of households could be saved, assuming that all the households accepted the options.

In the following section, an overview is provided of the use and acceptance of reduction options at the functional level of households.

6.3 Functional factors

To reach conclusions about this study's overall premise, the following questions relating to the functional level were formulated:

(2) *a. How are practices and willingness to accept single reduction options related?*
b. What are the determinants of the practices and the willingness to accept single reduction options at a functional level?

[30] The affected options were pre-rinsing of dishes, water-saving shower heads, sharing a car, a lighter car, fully loaded washing machine, fully loaded dryer, selective use of the dryer, most efficient dryer, and spin-drying.

> *c. What is the relation between practices and willingness to accept energy reduction options, when extended to an aggregated level?*

These questions were answered in Chapters 4 and 5.

Relation between practices and willingness to accept single reduction options

It was found that the relation between practices and willingness to accept depended on the nature of the reduction options. This raised the question as to what makes households actually change their behaviour, and therefore it was interesting to investigate further the determinants of both behaviour and willingness to change.

In Chapter 4 it is shown that in the case study approximately one-third of the tested relations between practices and willingness to accept options to reduce energy consumption were statistically significant. In particular for energy-unfriendly drying characteristics, more willingness existed for change. For textile use this relation was reversed: More energy-friendly textile use related to more willingness to increase this.
These results are confirmed in Chapter 5, in which relations are investigated in more detail. More relations (i.e. two-thirds) turned out to be significant. Again, a twofold conclusion can be drawn:
- On the one hand, a negative relation was found: Namely, more energy *unfriendly* behaviour was related to *more* willingness to accept reduction options. Options were impersonal, small routines within households, which did not require too much effort to start or to acquire, and demanded relatively low sacrifices in the use phase (e.g. selective dryer use);
- On the other hand, a positive relation was found: More energy-friendly behaviour was related to *more* willingness to accept. This regarded reduction options in which personal preference, taste, and norms had a larger part, tended to be outward oriented, and had aspects of status and social position: for instance, the choice of holiday accommodation, eating certain types of meat, or type of car ownership.

Each type of relation was equally represented. For the remaining third portion—those relations that were not significant—no clues could be found as to whether this had to do with the type of reduction option. This answered the first question (2a).

Determinants at the functional level

Using a factor analysis, the determinants of behaviour and willingness to change that were found at a functional level in de case study were:
(1) A possibility to choose (e.g. a tumble dryer can only be used less if it is present);
(2) Social status, which influences behaviour;
(3) Perception of a problem and the desire for a solution (e.g. one has no space to dry laundry on a line and therefore chooses to use a dryer);
(4) Positive experiences with previous changes;
(5) The wish to keep practices as simple as possible, and the habit of doing so;
(6) Aspects that influence demand (e.g. a larger household has a high wash frequency);

(7) One variable was not included in one of these seven factors and was thus included as a factor on its own. This was 'heating of the space where laundry is line dried';
(8) Willingness to accept alternative solutions and unrelated reduction options.

These eight determinants explained 65 percent of the variation in willingness to accept energy-reducing laundering options at a functional level.

In the general survey, it was investigated whether the indirect and direct energy reduction options cost less, the same, or more effort, money, knowledge or time to acquire or use; for the top group (15% of the respondents most willing to accept) and the mainstream group (85% of the respondents).
It was concluded that the top and mainstream groups differed with regard to their considerations about indirect and direct reduction options, mainly with regard to effort, image, and design aspects.
Respondents were divided about whether more knowledge was needed for indirect reduction options; for direct reduction options, the time and effort needed to acquire knowledge was not an important consideration.

Relation between actual behaviour and willingness to accept on an aggregated level

For the case study, an aggregated measure for acceptance was constructed of eleven options. This variable Acceptance was related to four practices about flexibility in changing situations and to the ability to perform tasks simultaneously. Combining laundering with household tasks was significantly and negatively related to this aggregated measure. This relation indicated that the organisation of the household influenced the acceptance of reduction options in general, which validated the notion that in the general survey more attention to the organisation of household management was needed.

In the general survey, aggregated variables were constructed for both practices and willingness to accept. Analyses were done for the total sample, a top group (15% of the respondents most willing to accept) and a mainstream group (85% of the respondents). The aggregated measures of practices and acceptance were positively related to each other (i.e. more energy-friendly behaviour was related to more willingness). This relation was much stronger in the top group than in the mainstream group and the total sample.

This answered the third research question (2c).

The overall conclusion was that a top group existed for whom energy-friendly behaviour was related to the willingness to further increase this; and a mainstream group existed that was more selective in what it wanted to change or not: (1) relatively impersonal indoor routines had space for change; (2) with personal taste or outward oriented options, households have a more positive attitude if they already applied the option, but their preferences for these options were diffuse.

6.4 Organisational factors

The following question was formulated with regard to organisational aspects:

(3) *a. How are characteristics of household management at an organisational level related to practices and the willingness to accept reduction options?*

For the analyses of the environmental friendliness of household practices, a distinction was made between the top group (17% of the respondents who were the most environmentally friendly) and the mainstream group (83% of the respondents). Four explanatory organisational factors were found:

(1) The respondent having a paid job (for the mainstream group);
(2) The use of commodities (for the total and mainstream group);
(3) The use of household help (for the total and mainstream group);
(4) The Frequency of Confer (for the total and mainstream group).

The environmental friendliness of the household practices was further explained by three non-organisational determinants: firstly, education of the respondent (for the total and mainstream group); secondly, whether the environment already played a role in household tasks (for the total sample); and thirdly, knowledge about the reduction options played a role, in particular for the top group.

For the analyses of willingness to accept, a distinction was made again between the top group (15% of the respondents most willing to accept) and the mainstream group (85% of the respondents).
The two organisational factors of influence on willingness to accept reduction options that were found were:

(1) The number of times that routines and household activities were combined (different signs for mainstream and top group);
(2) The Frequency of Confer about household tasks (for the top group).

Willingness was also explained by whether the environment already played a role in household tasks (different signs for the mainstream and top group) and further by the age of the respondent (mainstream sample), the number of children living at home (different signs for the total and mainstream sample), and finally by the actual energy friendliness of household behaviour (top group). Three of the six determinants had a different influence (positive or negative) on willingness to accept in the mainstream and top groups.

It was concluded that a relation existed between certain aspects of household organisation, the energy friendliness of household behaviour, and the willingness to accept. Which aspects were important differed for the top and mainstream group. In the explanation of the variation in willingness to accept, the direction of the effect of three determinants differed for the top and mainstream group.

6.5 Behavioural change after a year

After relations were found between willingness and behaviour, as well as the determinants of these on a functional and an organisational level, the question remained as to whether households in the general survey actually applied what they had intended to do in the general survey. For this, a follow-up survey was carried out a year later.

(3) *b. How many and which reduction options are accepted?*
c. What are the determinants of the eventual acceptance of change?

Households were asked whether they had considered, tried, and succeeded in adopting reduction options. To check whether households did what they had said and to detect bias in the findings in self-reported change, two comparisons between the general and follow-up survey were made. Firstly, a comparison was made between the self-reported environmental friendliness of household behaviour in the follow-up survey and the actual behaviour in the general survey. Secondly, a comparison was made between self-reported change in the follow-up survey and willingness to accept in the general survey. For both comparisons, a slightly positive relation was found, indicating that at least the *direction* of what people claimed to do could be trusted.

In Chapter 5, it is shown that on average 19% of the households in the follow-up survey changed at least 12 behaviours[31]: using more energy-saving light bulbs, plants or gifts instead of cut flowers, using conserved vegetables instead of ones that had been pre-frozen or imported, driving less or using bicycles or mopeds more often, washing at lower temperatures, using textiles longer and using the dryer less frequently, taking holidays closer to home, and heating at 1ºC less. These options were adopted by at least 15% of the respondents, and turned out to be of a repetitive character. The five most popular investments[32] were: water-saving shower heads, natural floor materials, a lighter car, energy-efficient appliances, or non-replacement the freezer.

The determinants of self-reported change and the perception of the environmental friendliness of the original behaviour were:

- Self-reported change in the follow-up survey was influenced by the willingness to accept changes in the general survey. This leads to the conclusion that intention can indeed result in behavioural change. Other determinants were: the extent to which the environment was taken into account, having a paid job, age of the respondent, use of commodities (appliances), and religion. As compared with the determinants mentioned in §6.4, religion was the only new determinant.

[31] Of the households (24.6%) that considered the 31 reduction options, at least 60% (on average 77.1%) succeeded in implementing 12 of them. These 12 options were thus adopted by an average of 24.6%*.771=19% of the households and by at least 24.6*.60=15%. See Table 5.58.
[32] Applied by an average of 12% of the respondents.

- Like the environmental friendliness of household behaviour in the general survey, the perception of the environmental friendliness of this behaviour ('I had/did that already') in the follow-up survey was influenced by three factors: (1) knowledge relating to options, (2) the extent to which the environment was taken into account, and (3) how the importance of household task results was perceived (also a new determinant).

The regression analyses reported in Chapter 5 demonstrated that the difference between self-reported environmentally friendly behaviour (follow-up survey) and actual behaviour (general survey) was a result of how the importance of household task results was perceived. Furthermore, the difference between the self-reported change in behaviour (follow-up survey) and the willingness to accept changes (general survey) depended upon whether people were more religious. The higher the scores on the determinants 'importance of household tasks' and 'religion', the higher the perception of environmentally friendly household behaviour and the reported change, respectively.

6.6 Clustering of reduction options

The possibility to form clusters of reduction options was investigated because it was considered it would provide an insight into the preference patterns of households. In principal, addressing several options at once is easier and would be more cost-effective for policy makers. To investigate whether clusters of reduction options could be found and categorized, the following questions were formulated:

(4) *Is it possible to form a typology of clusters of reduction options?*
If so, which reduction options make up these clusters?

Possibilities to cluster reduction options were limited. In general, it can be said that, at the most, two or three options could be carried out simultaneously, but no clear patterns were found regarding which options could be combined.

6.7 Answering the overall research question

The overall research question was:

(O) *What is the influence of household management on the acceptance and energy-saving potential of greenhouse gas reduction options?*

It can be concluded that household management influenced acceptance and energy-saving potential.

Eight influencing factors were found at the functional level. These demonstrate the influence of having a choice, of social status, of aspects that determine demand, of problem perception, of experiences with other changes and of the desire for simple solutions. At the organisational level, factors such as combining tasks, the respondent having a paid job, and conferring between partners appeared to influence the acceptance of reduction options. In addition to functional and organisational determinants, in particular the age and number of children living in the household appeared to influence acceptance and energy-saving potential.

For laundering, a 10% energy saving was theoretically possible, and in Chapter 4 it is shown that in practice this would amount to 3-4%. For the practices investigated in Chapter 5, theoretically one-quarter to one-fifth of household energy consumption could be reduced if reduction options were applied. However, the percentage of households that accepted the options was much lower than 100%, and the extent to which options were finally adopted per household was influenced by the willingness to accept and by its determinants.
The implications of this study's findings are discussed in the following section. Subsequent to an initial technical discussion of the methodology and analyses, theoretical and societal relevance as well as policy implications are examined. This thesis then concludes with recommendations for future research.

6.8 Discussion

6.8.1 Discussion on methodology: data collection

Case study

The recruiting methods used for the case study could have influenced the representativeness of the sample. The key variables that deviated from the Dutch average for families were education and part-time work: men and women were somewhat higher educated and a higher percentage of the women worked part-time (i.e. fewer than 20 hours, see Table 4.7). It was decided not to weigh for this.

General survey

Selectiveness may have occurred in the general survey, since people had to respond to an advertisement themselves. The representativeness of the sample was checked on demographic variables against the data on the Dutch population. This showed a slight over-representation of more highly educated, unemployed women. It was decided not to weigh for this fact. This over-representation might have influenced the sample score on environmental awareness. Scores on the Environmental Awareness scale (Couvret and Reuling, 1998) were compared with scores for the Dutch population. Results were comparable and showed no selectiveness. Since none was shown for environmental awareness, there was no reason to expect a measurement bias due to the method of data collection or over-representation of more highly educated, unemployed women.

Follow-up survey

The follow-up survey was held among the same respondents as the general survey, and 62 percent of the questionnaires were returned: 62 percent of the mainstream group and 64 percent of the top group. Compared to the responding group, of the group that did not participate in the follow-up survey the partners had on average a higher education and members of the household tended to be at home for fewer hours. Furthermore, the division of household tasks between partners was slightly more equal for the non-response group, and they had less liked to fill in the questionnaire. No difference was found in environmental awareness, actual environmental friendliness, or willingness to accept. The selectiveness in the follow-up sample therefore could have influenced the regression results of the follow-up survey with regard to organisational aspects. For example, Frequency of Confer, the number of combinations of tasks (both influenced by education and hours away from home [see Tables 5.46 and 5.51]), and having household help were part of the regression solution for the dependent variables of the general survey but not of those for the follow-up survey.

Dependent variables in the follow-up survey were explained with variables of the general survey, which had been measured a year earlier. Only self-reported behaviour and change were measured in the follow-up survey. This was because there was no intention to change determinants of behaviour with the set-up of the questionnaires and with the summary, and it was not expected that organisational aspects would change drastically within a year. In addition, it was assumed that more data with expected minor differences in similar variables would lead to less insightful results, whereas a shorter questionnaire with different questions would be more attractive and easily filled in and returned. This was expected to lead to a higher response rate.

6.8.2 Discussion of methodology: analysis

Case study

With hindsight, it is clear that laundering behaviour was measured in too detailed a manner. Although it was possible to describe households individually, it became difficult to aggregate and scale the data.

Many variables and interrelated practices contributed to the laundering process, which turned out to be highly complex; thus, a comprehensive laundering model could not be constructed. A step-by-step attempt was made to find other patterns in the data, and in the end the most relevant laundering variables were selected. Variables concerning willingness to accept reduction options along with a selection of correlated variables were input for an exploratory factor analysis. On the basis of this analysis, a clear pattern of eight insight-giving factors arose. Although this use of factor analysis might seem artificial, the results indicated that a pattern existed in the data at a functional level.

General survey

Three sets of reduction options are discussed in Chapter 5: those that related *positively* to energy-unfriendly behaviour; those that related *negatively* to energy-unfriendly behaviour, and those with no significant relations. The lack of significant relations was probably because the variables did not match closely enough. For example, the option 'water-saving shower heads' and the use of 'm^3 gas' were not significantly related. 'Frequency of taking a shower' was more likely to relate significantly to the option 'water saving shower heads', but this was not asked about in the questionnaire.

General and follow-up survey

Two main independent variables were constructed from the general survey data: Combining of household tasks and Frequency of Confer. These variables were used the analyses of the general and follow-up survey.

The scale measuring how many times per year people combined certain tasks within their households was constructed to determine whether people with more skills to combine certain tasks could handle a more complex household and accept more options. In the end, the scale did not measure complexity per se. In fact, it was constructed as a straightforward measurement of how often tasks were generally combined. There was no order in the complexity of tasks or in the difficulty of combinations. The frequency of each combination weighed equally in this scale, although in practice some combinations might have been more common than others. However, because of the way the variables were assessed, for the purpose of this thesis only a crude measure was made of how often people combined tasks, no matter what they were.
Using this scale as an explanatory variable, it was shown in the analyses that even this crude measure had a substantial effect on the willingness to accept reduction options. This gave enough reassurance that the scale was internally valid. Nevertheless, further study is needed, especially since the results using only this rough measurement were so promising.

Frequency of Confer was included in the questionnaire as one of the indicators for household organisation. The question 'Is there much conferring between you and your partner about household work and planning and arranging activities?'—was inherently geared towards people with partners. Since 18% of the respondents turned out to be single parents, this could have led to a problem. However, the single parents in the sample largely answered the question. They may not have had a partner but they did confer with their children about household tasks. Since the objective was not to measure relationships between partners but the way households were organised, the decision was made to include single parents in the analyses. Rather than losing 18% of the data, or including a variable that made a distinction possible between these groups and thus lose statistical power, it was chosen to include all respondents who answered the question. The objective of finding an indicator for household organisation was still met. There was no theoretical reason to expect differences between families and single-parent households in the way Frequency of Confer could influence the willingness to accept or the use of reduction options.

In the regression results for the follow-up survey, Frequency of Confer was not present, in contrast to the regression results for the general survey. The follow-up sample consisted of households that were away from home more often (and conferred more frequently, see Tables 5.46 and 5.51), but no difference existed in the participation of single-parent households. This assured that for Frequency of Confer, which was found to be an important determinant in the general survey, the effect was not over-estimated and was more related to being away from home than to the household being a single-parent one.

6.8.3 Theoretical relevance

Relations between practices and willingness to accept

It has been shown many times in social sciences that it is difficult to influence behaviour except when the reason for the discrepancy between behaviour and willingness to change is known. When people already use certain reduction options it might be because they have given it serious thought for environmental reasons. It is also possible that people use certain options but have not consciously considered their use. Nickerson (2003) refers to several authors who state that attitudes might guide behaviour even when the individuals whose behaviour is being guided are not aware of it. People might be using options and not be willing to increase the use for several reasons other then environmental ones. When options are not used, it could be because people are unwilling for different reasons or because they are not familiar with the options. It is possible to find the difference between people who behave consciously and who do not when the willingness to use or to increase the use of certain options is included, as well as the knowledge and the eventual change. The relation between actual behaviour and willingness to change, as well as their determinants, are thus important to show differences between groups of people and the reasons for discrepancy between behaviour and willingness to change.

Firstly, the relation between behaviour and willingness to change points to a possible typology with regard to energy awareness. Due to the twofold relationship between behaviour and willingness, which was found in this research, more is known about what types of behaviours can be changed in which direction; the relationship also gives information about the energy-saving potential within households. In the case of behaviour that is prone to personal preferences or taste, another approach is needed to influence the behaviour, and interventions will have a smaller audience. This is in contrast to repeated indoor and impersonal behaviour for which people see a positive outcome, and that is not difficult to carry out but can also be forgotten more easily. Interventions should also take into account that factual behaviour may already have reached a maximum possible value.
Secondly, by using a survey that was followed up by another one it was possible to determine whether it was unfamiliarity or other reasons that caused people not to apply certain options, as well as what kind of options were popular in both surveys.

The existence of the relationship between behaviour and willingness to accept is reassuring, since it enables the possibility to influence change. It provides information about the space for change and about the inclination to behave in a certain way (whether conscious or unconscious). The relation also facilitates a clearer understanding of which options are associated with willingness to change and that would lead to actual behaviour modification. The results gave directions for group segmentation based on the number and type of options that were preferred in relation to the actual energy friendliness.

Functional level

Energy research has mostly been done at the level of individuals or sometimes groups, but has hardly ever zoomed in on the black box of household activities. Collecting data at the functional level of actual activities, as was done in this research, provided the opportunity to discover new explanatory factors. In other words, the empirical approach of everyday life led to thoroughly founded factors that explain behaviour and the willingness to change.

For the case study, analyses at the functional level, with a broad, explorative bottom-up approach (analysing detailed practices), led to eight aggregated factors that played a role in the combined issue of behaviour and behavioural change. It can be assumed that the eight factors are relevant in other behavioural change issues as well, because they refer to general aspects and characteristics of households. These factors covered situational, limitative, motivational, normative, and operative determinants, most of them measured *through practices* at a functional level. For example, attitudes, values, and norms could be deducted fairly well through what was done at the functional level, as they became visible in some of the factors. Consequently, for behavioural change strategies it means that focusing on attitude, for instance, is not sufficient because other, practical factors are also at work. In an integrated approach, including a solution to a problem, these practical factors need to be taken into account to find new ways to change behaviour.

The seventh factor, 'heating of the space where laundry is line-dried', is interesting theoretically and in terms of energy. There was an indication that, for the respondents, heating was a topic on its own: In the follow-up survey, heating 1°C less was the only reduction option that was applied more often by the respondents than had been intended a year earlier in the general survey.

It is interesting theoretically because this single variable could refer to space heating habits—but for which no other practices were measured in the case study—or to comfort in general. Above all, this seventh factor reflected a relation to activity patterns and space use in the household. Literature that describes the relation between activities in the house, comfort standards, and space heating is scarce (Lutzenhiser, 1993). As found in the case study, heating of the dry space was related to the woman having a higher social economic status. In a study on heating patterns (Leidelmeijer, 2002), a relation was found as well between higher incomes, more rooms, and heating at higher temperatures at night. This study also revealed that family households with average and higher-than-average incomes, and household members who worked at home, had a higher than expected surplus energy requirement for heating, which might have been a result of different activity patterns.

In terms of energy, it is interesting because compared with the savings that could be achieved by applying laundering options, heating 1ºC less and heating fewer rooms could potentially save more energy. The results of the case study and the general and follow-up surveys indicated that heating patterns could be related to different household activity patterns and space use. However, this does not imply that these relations cannot be overruled: The possibility to heat fewer rooms and at lower temperatures existed in the survey results.

Organisational aspects

For the general survey, the aggregation of detailed measured practices and willingness to accept provided a good basis to explore the influence of organisational aspects.

To organise the various activities of several household members simultaneously; can influence the functional level of activities as well as the willingness to change them. Therefore, it was important to investigate the organisation level of the household.

Five organisational aspects were found that influenced the energy friendliness of behaviour, the willingness to accept, and the self-reported change. These were the number of task combinations, the Frequency of Confer, the respondent having a paid job, the use of household appliances such as a dryer, a freezer, and a dishwasher (commodities), and the use of household help. These organisational aspects pointed to the differences in dealing with many household tasks and the availability of choice. The fact that five organisational aspects were found that influenced willingness to accept, as well as energy friendliness of behaviour, is new in comparison with the literature (with the exception of the respondent having a job). In particular, the combining of tasks and Frequency of Confer are interesting:

– Possibly the number of combined tasks and the perception of combining tasks are related to the skill to easily shift from one task to another (leading to a lower sense of 'combining') or to the skills to perform complex routines, to mental accounting of groups of activities, or to lack of practical intelligence to oversee, separate and organise sequential tasks. It can also be related to how many activities are undertaken in the first place and for which blocks of time and attention are reserved to reduce the feeling of pressure. Skills in planning, flexibility, attention to alternatives, and multi-tasking can be related or be similar concepts. On the basis of the results, no statements can be made with certainty;
– As described in §3.4, §5.2.1, and §5.6.1 and based on the work of Kirchler *et al.* (2001) and Pennartz and Niehof (1999), it was expected that more frequent discussion and interaction between the several household members would lead to an easier change in how tasks are carried out. This might involve a smoother transition to more energy friendly behaviour. However, the opposite was found. A higher frequency of confer was related to having a job, to more work hours, and to a more equal task division. This points to a need to gear activities to each other and to the need for more routines so that less confer is needed and options can be implemented. Apparently routines are needed for more space to accept changes in other fields of activities.

Organisation of household activities also occurs at a mental level. Antonides *et al.* (1996) found that household activities were ordered by respondents in three dimensions (indoor and outdoor; frequent and infrequent; travel for work and travel for leisure), and advised that energy-saving policies should focus on these categories. In this thesis, the items that measured organisational aspects were assessed using factor analyses. These yielded a threefold division in household activities: indoor and outdoor activities; daily routines and long-term planning; and social and leisure activities and obligatory tasks (work and study) (no specific travel items were included). With regard to the categorisation of household tasks, the results of this thesis point in the same direction as the research results of Antonides *et al.*, and they can provide a sound basis for energy policy (see section 6.9).

Mainstream and top group: opposite relations in willingness to change

It was found that the same determinants had another role in the top and mainstream group. Apparently there is a threshold as to what households can deal with in particular in the mainstream group. This threshold is probably influenced by the number or by the *perceived* number of combined household activities, by taking the environment into account in household tasks, and by the number of children. The groups also considered reduction options differently. This is seen in Chapter 5 (§5.7.2.) where the proposed reduction options are valued differently by the two groups. These findings confirm that the theories of Rogers and Moore can also be applied to households and to their energy-related behaviour.

Popularity of repeated behaviours compared with other types of options

As found in the follow-up survey, the most popular energy reduction options were repeated behaviours. In the general survey these were labelled as impersonal routine indoor practices. These results can be influenced by a number of factors. Firstly, repeated routines are not registered in mental accounting (Kahneman and Tversky, 2000), and small changes in routines are overvalued (Lutzenhiser, 1993). It is therefore relatively easy to maintain a positive self-perception regarding routines and they are more easily 'not accounted' for (i.e. not mentally registered). This makes it easier to say that change has occurred, when in fact there is no change or only small changes take place.
Secondly, the positive results in the follow-up survey could have been influenced by the fact that households that enjoyed the questionnaire and who had available household 'time' as well participated in the follow-up survey. This made it likely that they had actually applied the reduction options to some extent.
Another factor that played a role was the influence of a more positive self-perception (see the discussion of self-reported behaviour). This means that the opinion about people's changed behaviours cannot be taken too seriously. The literature has shown that comparative feedback, self-monitoring, information, goal setting (target agreements), and rewards can change repeated behaviours (Braam *et al.*, 1995; Lutzenhiser, 1993; Koolen and Oostdijk, 2004; Uitdenbogerd and Egmond, 2005). Apart from shifting the 'locus of attention' (McCalley in Heijs, 2000), apparently these intervention methods influence or overrule one's self-perception of 'doing well enough'.

The magnitude of the change and familiarity with the options might also have been of influence. Velthuijsen (1995) investigated ranges of investments by firms. He found that the majority of firms applied the smaller investment options first. Investment behaviour requires conscious and reasoned decision making; according to Velthuijsen, options that are installed are not necessarily the most profitable or the ones that are advised by technicians, but are ones that are already well known. If the results apply to households, it could be expected that smaller familiar and repeated behaviours are changed first, which indeed was found in this thesis. The least applied options were disinvestments. These findings argue for different approaches with regard to repeated behaviours and to investments and disinvestments.

Clustering of accepted options and the relation to lifestyle research

No clusters of accepted reduction options were found in this research. In the discussion of the results and the literature in Chapter 5, several explanations for the lack of cluster possibilities are found. The only clear 'clustering' result was that options for repeated behaviours were more popular in the general survey and more often successfully applied in the follow-up survey.

The absence of clustering is a reason to make a comparison with results of lifestyle research that was related to housing and to energy policy issues. Lifestyle research clusters, for example, sets of behaviours that theoretically differ as to how much energy is required. However, neither lifestyle nor value patterns were clearly related to choices in housing and energy requirements (Heijs *et al.*, 2005; Vringer, 2005). The relation between housing environment and lifestyles was unclear; the preference for the housing environment could be based on reasons other than lifestyle, and different lifestyles co-existed in the same housing environment (Heijs *et al.*, 2005). Vringer (2005) also concluded that there was no significant relation to value patterns or to environmental commitment in the energy requirements of the consumption patterns of 2300 households. Only the 'least motivated to save energy' group required about 4% more energy than the moderately and highly motivated group, and 'materialists' used 7% more energy for their dwellings. Leidelmeijer (2002) found that mainly families with an average or higher income and 'home workers' had a surplus energy (gas) requirement that could not be explained by dwelling or household characteristics, such as household size. Apparently something like a 'family culture' in activity patterns determined the higher energy requirement. This is a neglected field of research in lifestyle and value studies. What happens in the household is likely to determine the unexplained variation of energy requirement and might be related to the diversity in households, which is one of the reasons no clustering of accepted reduction options was found. In short, it seems almost impossible to cluster energy-related behaviours or choices for energy-saving options on the basis of lifestyle, value or plain preferences. Explanations for this diversity might be found in the way household activities are organised and discussed, in combination with demographic and external situational factors.

Results of the general survey showed that about one-third of the variation in actual energy friendliness of behaviour was explained by (1) practical solutions that were related to time constraints (use of commodities, use of a household help, Frequency of Confer, (2) knowledge of the reduction options and education, and (3) the extent to which the environment was taken into account in practices. These influences are likely to be both habitual and situation dependent at the same time, and family or household culture plays a role in the sense that complicated situations can be solved in different ways.

Antonides *et al.* (1996) found that in categories in which energy reducing options were already applied more effort was experienced to increase this, regardless of how broad these categories had been defined by the respondents. Therefore, clustering based on preferences or within activity categories seems practically impossible. Implying more than one option would thus depend on which options are most familiar and on the situational and managerial factors of a household. As a result, implementation would require an individual approach and would lead to undefined combinations of options.

Self-reported behaviour

The role of religion in the explanation of self-reported change in the follow-up survey is interesting to extend upon. In *The Psychology of Religion – an Empirical Approach*, Hood *et al.* (1996) described some 246 studies of the role of religion in actual behaviour, such as 'cheating', 'child abuse', and so on. The authors stated that many studies rely on self-reports of behaviour. There were indications that religious people outside the religious context say they are more honest and helpful, and report an ideal image of themselves, but measurements of actual behaviour do not support this. The relations might be influenced by how religiosity is measured. Hood *et al.* state that the style of being religious—which is likely related to personality variables—might be more influential. Ester (1979) found that orthodox-oriented respondents were less environmentally aware than liberal religious respondents. However, whether orthodox or liberal, church membership or attendance made no difference in the actual environmental friendliness that was measured at a functional level (Ester, 1979). However, in most studies, religiosity was examined in a very general sense: for example, by church attendance and affiliation (i.e. connection with type of religion). Something similar was done in the general survey and a similar relation between religion and self-reported behavioural change, as described by Hood *et al.*, was found. The results at the functional level, were comparable with those of Ester (1979). Assuming that environmentally friendly behaviour is 'moral' and in this way can be compared with the behaviour studies by Hood *et al.*, the discussion above confirms that self-reported religiosity influences the perception of self-reported change in environmentally relevant behaviour. More generally: Beliefs about behaviour influence the *perception* of behaviour rather than one's *actual* behaviour.

In the case study and general survey, other indications were found that beliefs about behaviour did not highly influence the actual energy friendliness of that behaviour but rather the perception of its environmental friendliness. In the case study, this concerned the reasons for loading and choosing washing temperatures, as well as the perception that household members—by their article use—influenced laundering in relation to washing frequency. In the general survey, this concerned the perception of the importance of household tasks in relation to the self-reported environmental friendliness of behaviour.

The methodological consequences of this are that religiosity needs to be measured at a functional level in terms of style and actual environmental friendliness needs to be corrected for self-perception.

6.9 Implications for society and environmental policy

Empirical detailed research on actual and energy-relevant behaviour has seldom been done. Because two surveys were conducted, one in-depth (case study) and one with a broad set-up (general survey), the results that pointed in the same direction (e.g. the role of combining activities, having a choice, the wish to keep practices as simple as possible, and applied environmental awareness) had a surplus value and deserve to be elaborated upon. The findings are valuable in a general sense and confirm that both the functional and organisational level of household management are influential.

In addition, results were discussed in relation to several other research perspectives of behavioural change. The explorative perspective of household organisation indicates where to go for extra information on the ever-emerging question as to why willingness to change does not lead, or only marginally so, to actual change in households, and what to do about it.

Practical circumstances, continuing and extending habits, knowledge of the reduction options, and self-perception are aspects that interventions can make good use of. In practice, this means that three foundations must be laid to achieve behavioural change:

(1) A change in the valuation of how the environment already plays a role in household tasks and the perception of how energy friendly the household behaviour is (e.g. through feedback[33]);

(2) An increase in knowledge about behaviours that reduce energy consumption, in particular distinguishing for daily routines vs. disinvestments and investments (long-term planning), and taking further into account indoor and outdoor activities; social and obligatory activities; and impersonal vs. personal and status-oriented options;

(3) A decrease in complexity and time constraints within households by coaching on routines and easy-choice options for investments.

Segmentation of the population should be taken into account (the top and mainstream group as well as social status and age). At the functional level, having a choice, the problem, problem perception, experiences with other changes, the desire for simple solutions and the aspects that determine demand should be considered as well. For the top group, other measures should be taken regarding willingness to change: Knowledge is relevant here as well as options that do not need to be conferred about by household members.

Policy-makers should expect small incremental changes per household. Change in households increases time use and complexity, which could be bearable if other advantages prevail. These advantages are different for mainstream and early market groups. As discussed in Chapter 3, general campaigns have scarcely any effect. For instance, feedback measures and information could help change self-perception and increase knowledge; however, adding in-depth coaching

[33] The question in the first place is how to motivate these households to *check* their actual environmental or energy friendliness so that feedback can be offered, and in the second place how to *induce* them to begin small changes. It is likely that for this the ‘importance of household tasks’ and being religious as well as households’ perception of environmental friendliness in practice can be used. Whether this is ethical and effective remains to be seen, and it relates to the discussion about framing effects (Kahneman and Tversky, 2002; Cialdini, 2000; McCalley in Heijs, 2000): namely, how heuristics and feedback can be framed in negative or positive terms and can be used to reflect on the self, which if not used correctly can lead to ineffective strategies and damaging consequences.

on changing routines and decreasing the complexity of household organisation could probably result in even more and enduring effects. Time constraints and the desire for uncomplicated solutions argue for a structure that makes it easier for households to invest.

The relevance for society is related to the question of what to do to encourage households to use less energy in a household-friendly and cost-effective way. Apparently willing households have space to change, either with reducing impersonal repeated behaviours that are energy unfriendly or increasing energy-friendly behaviours that reflect more personal preferences. Generally speaking, behavioural change can be achieved through focusing on motivations, attitudes, emotions, and choice procedures; on personality characteristics, such as self-efficacy; the limitations, alternatives, incentives, or social influences in the environment; or on behaviour itself (skills, habits) (Kok, 2005). For this thesis, behaviour in the *black box* of the household was chosen as a field of study, completed with concepts from theoretical perspectives other than that of household science. It is a bottom-up approach to understanding a system on different levels by investigating functional activities and by aggregating concepts. Personality traits can be traced in some of the measured concepts and results, such as how respondents perceive themselves and their behaviour, and with how many combined household tasks they can deal. This thesis shows that the behavioural approach is of value to derive the concepts that determine household behaviour. Using variation in households (in behaviour, in organisation, in personalities, in motivations, in capacities, in habits and practices, and in situations) as a basis to work with the three foundations is probably a promising way to achieve behavioural change, in particular in the mainstream group. This type of approach acknowledges people's life choices, which can then be more easily addressed and in a more realistic manner.

6.10 Suggestions for further research

The case study and the general and follow-up surveys revealed certain issues that deserve closer attention in subsequent research.

Self reported behaviour, self-perception, and the role of religion

Self-perception emerged in the comparison of the general and follow-up survey regression results regarding actual behaviour and self-reported change. This has theoretical and methodological consequences for research about behaviour and for finding the appropriate clues to change behaviour. Self-perception in relation to actual behaviour deserves more research attention.

Age

The samples consisted of family households, implying a restriction to the variation in age. Despite this, age played a role in willingness to change (mainstream, general survey) and in self-reported change (follow-up survey). It is expected that age will have a more prominent role in, for example, a national representative study. Age was also found to influence energy saving in several other studies (Lutzenhiser, 1993; Antonides *et al.*, 1996). However, the relation to other factors that influence energy saving has not been investigated. As well as more *actual* experience and knowledge of reduction options and a general lower willingness to change, age probably influences the *perception* of one's environmental friendliness of behaviour and what change is needed or desired. The implications of age should be further investigated.

Children and willingness to accept

The role of the number of children in relation to the number of combined tasks is not clear. The positive correlation between these two variables suggested that the influence on willingness to accept (general survey) is at least equal in direction. However, contradictory results were found for the number of children, depending on the total sample (a negative influence) and the mainstream sample (a positive influence), which pointed to a curvilinear relation. Even more so, the influence of the number of combinations was negative for the mainstream and positive for the top group and total sample.
For the mainstream group a higher number of children apparently led to more intense housekeeping activities, resulting in more activities and more combined activities in the categories Clothing, Shopping, House, and Transport, whereas cooking was approached in an easy way, whereby less fresh vegetables are used. A higher number of children was related to a more extensive appliance use, such as a dishwasher, frequency of washing, dryer use, and use and capacity of freezers. For respondents with more children, the environment played a lesser role in the use of meat and the tumble dryer. More over, no relation to environmental awareness existed. The number of combined activities relating to the number of children differed for the top group: There were fewer children and more combinations than in the mainstream group. This could explain the positive influence of a number of combinations and the absence of the influence of number of children in the top group. However, the above does not explain why a higher number of children and a lower number of combinations are related to more willingness to change in the mainstream group. This phenomenon could be further investigated for the mainstream group.

Number of task combinations and organisation of household activities

To investigate the organisation of households, a number of aspects were operationalised in a quantitative way. As far as is known, this was a first attempt to explore the organisation of households in such a manner. Of the explorative aspects that were developed, in particular the number of combinations seems an interesting direction to be further examined. For the mainstream group more combining was related to a higher use of several pre-frozen products, the results of household tasks are more important, jeans and towels are used for less days and wash and dry frequency are higher. This gives an indication in which activity categories routines are different. Attention could be given to routines, to which activities and how many are carried out and combined, and to organisational variation in households in relation to the situation.

Functional data analyses

Measurements at the functional level appeared too detailed to aggregate easily, as activities and their outcomes were related in many ways. The eight aggregated factors that were found tell more about the functional influences on the performance and outcome of activities, and could be further explored. With these influences in mind, it would be possible to restrict the details in data gathering and data analyses in functional-level research.

Evaluation methods

To evaluate change in behaviour, it is important to quantify the behaviours at the functional level in the evaluation study as well. Only then can patterns of change be derived. This type of evaluation is also relevant for the implementation of intervention methods and understanding how they work. The definition of environmentally friendly behaviour also needs to be clear. If a household's self-perception of its behaviour is more positive than its actual behaviour, it is difficult to convince households that they need to change their behaviour.

Energy-saving potential at the functional and aggregated level

The domestic energy-saving potential at the functional level for the 31 investigated reduction options can be estimated. To determine whether the explanatory variables of actual behaviour and willingness to accept reduction options (found at the aggregated level) are useful to actually change behaviour, experiments are needed about what happens when the relations are dynamically influenced.

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List of Definitions

Acceptance (chapter 4 and 5)
The degree to which proposed reduction options were responded to positively

Application (chapter 5)
The extent to which the environment was taken into account in household activities; scale (ordinal) based on 11 items

Attractiveness (chapter 5)
The preference for each option when four were chosen from the range of 31

Considered (follow-up survey)
The number of reduction options that a household took into consideration; composed variable based on 31 items (ratio)

Combining (chapter 5)
Doing activities simultaneously; composed variable based on 10 items about combinations of tasks (ratio)

Direct energy
Energy consumption needed for processes, in a strict sense without the energy to produce this energy and not in primary energy terms, but used as such in consumption pattern research

Environmental awareness (chapter 5)
General attitude towards the environment; scale based on 6 items (ordinal); used in the National Monitor of Environmental Behaviour

Frequency of confer (chapter 5)
Number of times that household activities were discussed; composed variable based on 10 items (ordinal)

Home production (chapter 5)
Using products and services of the market vs. home production; composed variable based on three items to do with vegetables (ordinal)

Household
System relating to people, conditions, and material and non-material needs as well as the activities and processes in the activity categories Feeding, Clothing, Housing, and Personal Care, aimed at meeting the material needs and creating the material conditions for the non-material needs of household members in their daily life settings

Importance (chapter 5)
Experienced importance of the result of household activities; composed variable based on 11 items (ordinal)

Indirect energy
Energy consumption that was available for processes involving goods, materials, services, and so forth

Knowledge (chapter 5)
Knowledge regarding the 31 reduction options; composed variable based on 31 items (ordinal)

Laundry type (chapter 4)
Wash cycles with specific labels as defined by households referring to the sorting of the laundry by article type, material type, colour, likely in combination with washing machine programs, detergents, and temperature choices

Pleasure (chapter 5)
Pleasure experienced in carrying out household activities; composed variable based on 11 items (ordinal)

Task division (chapter 5)
Task division of household activities between partners; composed variable based on 11 items (ordinal)

Textile Care (chapter 4)
Includes laundering as well as additional treatments such as airing, repairing, and looking after the stock of textiles

Time (chapter 5)
Experience of having enough time for household activities; composed variable based on 11 items (ordinal)

Tried (follow-up survey)
Number of reduction options that a household tried, after consideration; composed variable based on 31 items (ratio)

Use of commodities (chapter 5)
Use of the freezer and/or dryer and/or dishwasher; composed variable (interval)

Use (chapter 5)
Environmental friendliness of 28 behaviours; composed variable (ratio)

New Use (follow-up survey)
Number of reduction options that a household applied successfully; composed variable based on 31 items (ratio)

Old Use (follow-up survey)
Number of reduction options that a household claimed that they had previously implemented or were still doing so; composed variable based on 31 items (ratio)

All Use (follow-up survey)
Sum of New and Old Use (ratio)

Willingness to change (chapter 5)
Willingness to apply 31 reduction options; composed variable (ratio)
Also used as in 'Acceptance'

Appendices

Appendix 2A Energy analyses methods

Hybrid energy analysis method

The hybrid method consists of the following steps (Groot-Marcus *et al.*, 1996):
- mapping the life cycle of the product,
- establishing the mass balance in the life cycle,
- establishing financial balances in the life cycle,
- determining energy requirements for the production of basic materials,
- determining energy requirements of the residual goods,
- determining energy requirements for the energy needed directly for product manufacturing,
- determining energy requirements for capital goods,
- determining energy requirements for transport and the trade sector,
- determining energy requirements needed directly for the use of products in the household,
- determining energy requirements for disposal of the product as waste,
- adding contributions determined in steps 4-10 to obtain the cumulative energy requirement.

Input-output method

With the input-output method, the household energy requirement is calculated using the following model:

$$E = r' D' (I-A)^{-1} y + r'd$$

E	= energy requirement of households
r’	= vector with energy requirements of energy (ERE) values for each energy carrier
D	= matrix with direct energy input of production sectors for each energy carrier
I	= unit matrix
A	= technological matrix
y	= household consumption vector
d	= vector with direct energy demand of household consumption for each energy carrier

Vector r corresponds to the conversion of energy in the energy sectors, part $D'(I-A)^{-1}$ corresponds to the energy efficiency and production structure of production sectors, and vectors y and d correspond to consumption patterns and energy use of households, respectively. Part $r' D' (I-A)^{-1} y$ can be seen as the indirect energy requirement and r’d as the direct energy requirement of households.

This model is also used to calculate the effect of energy reduction options. Each option corresponds to changes in one or more elements of the input-output model parameters. Technological options concerning energy efficiency improvements in both conversion and end-use are implemented by changing parameters r, D, and d. Options concerning changes in production processes to save energy (e.g. substitution of materials or changes in productivity) are implemented through parameter A. Changes in direct energy in household consumption patterns use parameter y.

Considering the detail level of the options, the input-output table should be homogeneous and have a low aggregation level. Sets of reduction options were implemented in the model by changing several elements of the model parameters simultaneously. A selection of the results is displayed in the following table.

Energy requirement, GHG emissions, total consumption, and employment in the Netherlands, relating to household consumption in 1990 (Wilting, Moll and Nonhebel, 1999)

		Consumption Netherlands	Consumption household sector*
Consumption	(.10^6 gld)		283912
Indirect e.r.	(PJ)		1037
Direct e.r.	(PJ)		706
Total e.r.	(PJ)	2722	1744
CO_2	(billion kg)	184	119
CH_4	(.10^6 kg)	1067	449
N_2O	(.10^6 kg)	63	26
GWP	(billion kg CO_2 eq.)	226	136
Employment	(1000 working years)	5203	3390

**The Dutch economy also uses energy and labour for other final demands (e.g. government consumption and exports). Not all GHG emissions in the Netherlands (e.g. CH_4 emissions of waste and N_2O emissions from water surfaces) are assigned to household consumption; energy used and emissions in other countries in favour of Dutch consumption are partly included. In 6.5.10^6 households, the energy requirement was 268 GJ/hh in 1990, calculated using the input-output method. According to Ros and Wilting (2000), and including imports and exports, the Netherlands uses 4300 PJ, 1300 PJ of which is imported, 2400 PJ (56%) is exported, and 1900 PJ (44%) is consumed by inhabitants of the Netherlands.*

Appendix 2B Compatibility of reduction options

	Heating less	Car use	Wash temperature**	Use of washing machine/dryer**	Pre-rinsing dishes**	Energy-saving light bulbs	Solar boiler	Green electricity	Shower head	Alternative appliances**	Holidays	Longer use of textiles**	Textile materials	Floor covering	Flowers/gifts	Meat**	Vegetables**
Heating less																	
Car use		●															
Wash temperature**																	
Use of wm/dryer**	*●	□	□	*●													
Pre-rinsing dishes**																	
Energy-saving light bulbs																	
Solar boiler			□	□	●												
Green electricity																	
Shower head							●										
Alternative appliances**			□	□			□			●							
Holidays		●									●						
Longer use of textiles**		□	□	*●													
Textile materials	*●		*●	*●								□					
Floor covering																	
Flowers/gifts															□		
Meat**										□							
Vegetables**										□							

*** analysed in both surveys; ● interaction in energy terms, or consequences for compatibility in application; ●* idem, effects quantified in (Uitdenbogerd and Vringer, 1999).*

□ possible interaction in use/practices/activities; this is not intended to be complete, but is an exercise in thinking of possible interaction effects in use.

Appendix 2C Summary of figures relating to reduction options

Household consumption requires 240 GJ/hh.y; the categories addressed in the table cover nearly 75% (176 GJ/hh.y). The total savings based on the various calculation methods are 17% (40 GJ) of the total household energy requirement. This does not include the solar boiler, 'no car', smaller washing machine, gas-fired dryer, and not using the tumble dryer, as they are incompatible with some of the other options. Including these options would lead to another 30 GJ reduction, but as other reduction options are affected the reduction potential is likely to be lowered by 7 GJ, leading to a potential of 26% (63 GJ). The affected options are rinsing of dishes, using water-saving shower heads, sharing a car, buying a lighter car, having a fully loaded washing machine and dryer, and using the dryer selectively as well as using the most efficient dryer and using spinning.

Reduction option	Use/Savings
User situation, household consumption	240 GJ/hh.y, 54% indirect, 46% direct
User situation, gas/water	
Heating	60 GJ/hh.y[a], average indoor temperature 18.2°C
Penetration rate solar boilers	0.5% (35000 in 1999)[5]
Rinsing	by 60% households; 84% warm and 80% warm flow[1]
Penetration rate water-saving shower heads	50%
Heating 1°C less[2]	Saves 4.8 GJ/hh.y[c] (7-8%)
Solar boiler[5]	Saves 6.4 GJ/hh.y[c]
Not pre-rinsing dishes[1]	Saves 0.6 GJ/hh.y (average)
Water-saving shower heads[6]	Saves 1.3-1.6 GJ/hh.y[c]
User situation, electricity	Use 3 bulbs/household; green electricity: 14% of households
Energy-saving light bulbs	Saves 0.5 GJ/lamp.y[13]
Green electricity	Saves 10-12% of total emissions related to e.r./hh.y[a]
User situation, transport	
Car	General: 11 km/p.d 3.7 MJ/euro[10], 28.9 GJ/hh.y[a, 10]; 4.1 MJ/car.km[8, 4], 16300 km/car.y[8], 66.8 GJ/car.y[b], weight 1995: 1010 kg[8]
Public transport	3.5 MJ/euro, 3 GJ/hh.y[a], 1.1 MJ/pkm[8], 21.10^9km/y, 1333 km/p.y
Bicycle	1.2 MJ/euro, 0.5 GJ/hh.y[a], 0.2 MJ/pkm[8], 1000km/bike.y
Cars and fuels options[10, 8]	
Sharing a car	Saves 1.7 GJ/hh.y[a] i.e.
Lighter car (1010->800 kg, saves 5%)	Saves 1.4 GJ/hh.y (5% = estimation)
Car →Public transport[10]	From '68% : 32%' to '48% : 52%' saves 1.5 GJ/p.y (3.6 GJ/hh.y)
Bicycle[10]	1000 km bike i.s.o. car saves 3.8 GJ

Not owning/not using a car	Saves ±20 GJ/hh.y[a11]
User situation, washing[2]	243 kg/p.y, 2.34 p/hh, 159 cycles/year, 575 kg/hh, 4 MJ/kg user conditions (2.3d+1.7i), 2.3 GJ/hh.y[b]
Washing of laundry options[2]	
Wash temperature 50°C->40°C	Saves 0.5 MJ/kg, 285 MJ/hh.y[b]
Full loads 3.5 → 5 kg	Saves 0.5 MJ/kg, 285 MJ/hh.y[b]
Smaller washing machine	1.9 MJ/kg i.s.o. 2.3 MJ/kg washing, saves 230 MJ/hh.y[b,c]
Wearing items longer	Every not washed load saves 9 MJ
E-buttons (10%)	0.1 GJ.hh.y
Most efficient washing machine (20%)	Saves 0.5 MJ/kg, 285 MJ/hh.y[b]
User situation, drying[2]	3.3 kg/cycle, 60% rH 6.3 MJ/kg laundry (5.6d+ 0.7i), 3.6 GJ/hh.y[b]
Drying of laundry options[2]	
Full loads 3.3 → 5 kg	Saves 0.6 MJ/kg, 214 MJ/hh.y[b]
Selective/seasonal use	Saves 0.2 GJ/hh.y (winter time use only)[b]
Gas-fired dryer	4.4 MJ/kg i.s.o. 5.6 MJ/kg, saves 0.7 GJ/hh.y
Most efficient dryer (20%)	Saves 1.1 MJ/kg, 0.3-0.6 GJ/hh.y[b]
Spinning 1100 →1300 rpm/60 →50% rH	Saves 1 MJ/kg, 0.2-0.5 GJ/hh.y[b]
No dryer or use of (includes ventilation)	0.7 MJ/kg i.s.o. 6.3 MJ/kg, saves 3.2 GJ/hh.y[b]
Extra space of 3.4 m²	+ 1-1.7 GJ/hh.y[c]
User situation fridges/freezers[1]	56% freezers-380 kWh/a.y, 46% two-door fridge/freezer-464 kWh/a.y, 35% fridge with freeze compartment-288 kWh/a.y, 30% without-226 kWh/a.y; 5.9GJ/hh.y[b] d.e
Cooling/freezing options[1]	
30% freezer + 30% fridge → 2 door fri/fre	464 i.s.o. 606 kWh/y, saves 0.4 GJ/hh.y
56% deep freezer → no freezer	Saves 1.9 GJ/hh.y
56% most efficient freezer (20%)	Saves 0.7 GJ/a.y
Most efficient fri-fre + fri-fre-comp. (50%)	113-144 instead of 226-288 kWh/a.y, saves 0.8 GJ/hh.y
Fridge/freezer in the cellar (present in 10% of the houses)	Saves 2.6 GJ/hh.y of those 10% houses; saves per average household: 247 MJ/hh.y
Smaller fridge (200→150 litres)	Most efficient 113 i.s.o. 175 kWh/y, 0.56 GJ/hh.y
Smaller freezer (200→50 litres)	200 kWh/y i.s.o. 380 kWh/y, saves 1.6 GJ/hh.y
User situation, food and meals	3365 euro/hh.y; 34[7]-41[10] GJ/hh.y
Food (general)	623 euro/hh.y; 70% eats outdoors, 9 times/year, 70% of households take-a-way per year, 15% of households order a meal[16]
Eating out	
Pre-processed meal (parts)	14% of households use pre-processed meal (parts)[17]
Spaghetti/Nasi/Dutch meal (4 p.)[12]	Use 43-87/67-105/56-108 MJ/meal, depending on level of pre-processed products

Meal options	
Eating together (3x less heating for 4 p.)[1,12]	Heating for 4 p. costs 25-45% of the d.e.r. for 4x1 p.
Halving eating out[1]	Saves 2.5 GJ/hh.y
Degree of pre-processed meals (4 .)[12]	Saves factor 1.05 (spaghetti types) – 2.16 (pudding types)
Degree of pre-processed meals (1 p.)[12]	Saves factor 1.3-1.7
Preparing for 4 persons i.s.o. 4x1 p.[12]	Saves 0-13 MJ/4 meals
User situation, textiles	4.9 GJ/hh.y[18]
Textiles options[2]	
More wool + maintenance	+2.6 GJ/hh.y (i.e) more wool, +0.3GJ/hh.y maintenance
More wool and heating 1°C less	Saves 4.8-2.9=1.9 GJ/hh.y
CO/PE bedding, cotton wash, synth.dry	4MJ/kg+ 4.8-5.7MJ/kg=8.8-9.7MJ/kg i.s.o. 10.3 MJ/kg; saves 0.3-0.9 GJ/hh.y
User situation, floor coverings	103 euro/y, 1.2 GJ/hh.y, 2.4 MJ/euro, 5 m²/hh.y[9] vinyl/linoleum 14%, other 10%[14]
Vinyl	118MJ/m², 12.7euro/m², 8MJ/euro, 1.7kg/m², (7%?), 60MJ/kg
Polyamide	204MJ/m², 15euro/m², 25MJ/euro, 2.2kg/m², 39%,170MJ/kg
Wool	65-126MJ/m², 24 euro/m², 2.7MJ/euro, 2.6kg/m², 11%, 25MJ/kg
Linoleum	35-82MJ/m², 20euro/m², 1.7MJ/euro, 2.3kg/m², (7%?), 15MJ/kg
Wood[9]/laminate	74MJ/m2, 28euro/m2, 2.6MJ/euro, 7.4kg/m2, (13%?), 10MJ/kg
Cotton[14]	230MJ/m2, 28euro/m2, 8.2MJ/euro, 2.4kg/m2, 97MJ/kg
Stone paving[14]	160MJ/m2, 15euro/m2, 10.7MJ/euro, 17.8kg/m2, 13%, 9MJ/kg
Floor covers options[8]	
5 m² (¾ polyamide/¼ vinyl) by (1/3 wood, 1/3 linoleum and 1/3 wool)	Saves 0.53 GJ/hh.y
User situation (> 3 nights) holidays	12.5 GJ/hh.holiday, 909 euro/hh.y, 600 hours/hh.y, 2.7 MJ/euro, holiday participation 1995 77%, 33.75 GJ/hh.y, 2.7
Average	holidays/hh.y
Domestic	80.10⁶ days, 7.7.10⁶ holidays, duration 10.4 days/person.holiday
Abroad	148.7.10⁶ days, 10.2.10⁶ holidays, 14.6 days/person.holiday
Top ten destinations; transport	F, ES, D, AU, B, GB, I, G, CH, CZ, 28% plane, 55% car, 14%
Accommodation	coach 20% tent, 20% apartment etc., 20% caravan, 10% friends/relatives, 10% youth hostels, boats, etc.
Holidays options[4]	
Using a tent	Saves 3-35% (3.4 GJ/hh.holiday)
Halving distances	Saves 26-48% (2.4 – 55 GJ/hh.holiday)
Halving distances + tent	Saves 6.1 GJ/hh.y
Holiday longer and further away but	Minimum example: once in 3 years with plane + five times

fewer	Netherlands in 3 years: 19.3 GJ/pp.y (34.4 hh.y)
User situation, vegetable consumption	Basic figures: production greenhouse vegetables 37 MJ/kg; production open ground 1.55 MJ/kg; frozen 8 euro/hh.y, conserved 33 euro/hh.y, 4.7 GJ/hh.y (fresh 2.6 GJ/hh.y, frozen 0.2 GJ/hh.y, conserved 0.7 GJ/hh.y, other 1.2 GJ/hh.y)
Vegetables options[7]	
Fresh vegetables (f.v)	Use 1.9-7 MJ/euro, 0.3-2 euro/kg, 4.9-46 MJ/kg
Frozen vegetables	Use 6 MJ/euro, 1.3 euro/kg, 42 MJ/kg; f.v. –167 MJ/hh.y
Greenhouse vegetables	E.g. tomatoes 7 MJ/euro, 43 MJ/kg, 1.3 euro/kg; f.v. –2.7 GJ/hh.y
Imported vegetables	?; f.v. –0.2 GJ/hh.y
Conserved	Use 3.4-4.5 MJ/euro, 22MJ/kg, 1.4 euro/kg; f.v. –0.2GJ/hh.y
User situation, cut flowers[15]	127 euro/hh.y for flowers, plans and garden plants, 7.1 MJ/euro, 4.4 GJ/hh.y; 77 euro for flowers, 250 flowers, 11 bouquets, 2.2 GJ/hh.y, 9 MJ/flower, 30% of the smaller gifts, 50% of the flowers are presents, 7 euro/bouquet, 70% of the households buy flower bouquets
Cut flowers options	
Gifts i.s.o. flowers (50% of the flowers)	Saves 0.9 GJ/hh.y (unweighted average of 1.4 MJ/euro)
Cut flowers[8]	5.9 MJ/euro (3-9MJ/euro)[15]
Plants[8]	3.6 MJ/euro
Flowers from bulbs (grown outside)[14]	1.4 MJ/euro
Books	1.1 MJ/euro
CDs	0.9 MJ/euro
Gift voucher	0.9 MJ/euro
Sweets, chocolate, liquorice	2.3 MJ/euro
Fruit, fruit juices	2 – 2.6 MJ/euro
Wine or other alcoholic drinks	0.5-1.8 MJ/euro
User situation meat consumption	2.5 MJ/euro, 7.8 GJ/hh.y, 77 MJ/kg, 7-11 euro/kg, 111 gr./pp.day
Meat and fish (generally)	Pork 50%, beef 20%, poultry 22%, other 4%, replacements 4%; 20% of the households buy replacements every now and then; meat/meat in products: 55/45, increasing to 25/75 in 2035[16]
Cheese	2.7[8]-2.9[7] MJ/euro, 2.3 GJ/hh.y, 59 MJ/kg, 4.5 euro/kg
Eggs	0.6[8]-3.7[7] MJ/euro, 0.4 GJ/hh.y, 31 MJ/kg, 0.11-0.28 euro/egg, 63 grams/egg, 3.09 euro/kg
Pulses, dried and conserved	4.5[8]-6.8[7] MJ/euro, 0.1 GJ/hh.y, 185 MJ/kg, 5.5 euro/kg
Chicken, poultry	1.9[8]-2.9[7] MJ/euro, 0.9 GJ/hh.y, 57 MJ/kg, 5.9 euro/kg
Fresh fish	3.9 MJ/euro, 0.9 GJ/hh.y, 106 MJ/kg, 9 euro/kg
Beef	2 MJ/euro, 0.65 GJ/hh.y, 103 MJ/kg, 10 euro/kg

Bacon, ham, pork products	1.8-2.7 MJ/euro, 1.8 GJ/hh.y, 70 MJ/kg, 9 euro/kg
Pork, minced meat	2.5 MJ/euro, 1.8 GJ/hh.y, 83 MJ/kg, 7 euro/kg
Vegetarian products/meat replacements	11-16 MJ/kg[16], 13.7 euro/kg
Tahu/tofu/tempé/soya	5 euro/kg, Soya basic good: 7.7 MJ/kg[8]
nuts	basic good: 15.7 MJ/kg[8]
Meat options[7]	
Consuming the advised amount, 100 gr[1]	Saves 0.5 GJ/hh.y
More vegetarian (30% less meat)	Saves 0.2 GJ/hh.y; includes substitutions by 33 grams of meat replacements (¼ cheese, ¼ eggs, ¼ pulses, ¼ wheat meal)
More vegetarian (30% less meat)	Saves 0.34 GJ/hh.y; includes replacement by 33 grams of (½ Soya products, ½ nuts)

[1]Brouwer, 1998; [2]Uitdenbogerd and Vringer, 1999; [3]Uitdenbogerd et al., 1998; [4]van den Berg and Vringer, 1999; [5]Vademecum Water, 1999; [6]Groot-Marcus, 1998; [7]Kok et al., 1993; [8] Kok et al., 2001; [9]Vringer et al., 1993; [10] Biesiot and Moll, 1995; [11] Vringer et al., 1997; [12]van der Locht, 1998; [13]Kramer et al., 1994; [14]Potting et al., 1995; [15]Vringer and Blok, 2000; [16]Kuijer and Wielenga, 1999; [17] Costa in: Butijn et al., 2002; [18] Uitdenbogerd, 1995; MJ/gld converted to MJ/euro, 2.2 gld = 1 euro

[a] based on average national expenditures

[b] based on average national use conditions

[c] for replacement of an appliance, for a theoretically average household

Appendix 2D Calculation of the theoretical reduction potential

This appendix describes the potential of energy reduction options that were included in the two major surveys. The reduction options are classified on the basis of two criteria: direct vs. indirect energy requirement and changes in use and practices vs. investments or purchases.

1. Direct energy requirement and changes in use and practices

1.1 Heating

In a Dutch household, heating uses approximately 25% of the total yearly energy consumption (both direct and indirect) (Biesiot and Moll, 1995). During the period 1986-1991, the average indoor temperature increased by 1°C (Weegink, 1994) from 17.3° to 18.2°C. Thanks to improved efficiency measures for heating in dwellings, the amount of gas used per household decreased, whereas the total amount of gas used in the Netherlands has not changed, due to an increase in the number of dwellings. The outside air temperature in wintertime is 7°C; therefore, during a 7-month period (the heating season is from October 1to May 1) the indoor temperature must rise by 11.2°C. This uses 53.7 GJ/hh.y, derived from the average amount of gas (1678 m^3, 32 MJ/m^3 [Weegink, 1994]) required for heating. Heating 1°C less could theoretically save 4.8 GJ/hh.y (Uitdenbogerd and Vringer, 1999).

1.2 Car use

Reduction options for car use are sharing cars, buying lighter cars, using public transport or driving less, using bicycles, mopeds, or motorcycles, or not owning a car or a second vehicle.

- Sharing cars means that fewer cars need to be produced. It is assumed that sharing a car with other households decreases the car's lifetime from 10 to 7 years. A household's expenditure on cars over a 10-year period needs to be made by two households over a 7-year period (Wilting *et al.*, 1999). The energy requirement is in total 61 GJ, which is then not divided into 10 years but into 2x7 years. This means a reduction of 1.7 GJ per household per year (Vringer *et al.*, 1993). Sharing cars will save nearly 1% of the total energy consumption of households (Wilting, Moll and Nonhebel, 1999). It is estimated that sharing a car through a leasing or leasing-related company leads to the same reduction potential.
- A smaller car saves both direct and indirect energy, whereas a lighter one will mainly save direct energy. The average weight of a car in 1994 was 1045 kg (Moll and Kramer, 1996). A factor of 0.7 gasoline is used per 100 km, for each 100 kg that a car is lighter in weight (Cornelissen, 1993). With an average of 16.300 km/car.year in 1994 (Moll and Kramer, 1996) this is 114 litres gasoline, or 3.6 GJ/year, saved when a car is 100 kg lighter.
- Public transport is diverse. The general indirect energy requirement for public transport is 0.2 – 0.35 MJ/km, due to the influence of the high number of employees. On average, the energy intensity for public transport (apart from trains and taxis) is 4.2 MJ/euro (Kok *et al.*, 2001). For trains, the total energy requirement (direct + indirect) is 1.07 MJ/pkm (Kok *et al.*, 2001). For city buses, the direct energy requirement is 1.5 MJ/pkm, the indirect e.r. is 0.35 MJ/pkm (Brink and van Wee, 1997; Hofstetter, 1992 in: Kok *et al.*, 2001), and the total is 1.87 MJ/pkm. According to Paauw and Perrels

(1993), of all the seats in public transport (trams, subway trains and buses) 80% of them are located in buses.

- A new bicycle costs 0.9-1.1 MJ/euro and maintaining it costs 1.3-1.4 MJ/euro (Paauw and Perrels, 1993; Kok *et al.*, 2001). Mopeds and motorcycles cost 0.9-1.1 MJ/euro (Paauw and Perrels, 1993; Kok *et al.*, 2001).
- The energy intensity of a car is 1.1-1.2 MJ/euro, whereas the energy intensity of the 'running costs' is 7-9 MJ/euros, which includes fuel (Paauw and Perrels, 1993; Kok *et al.*, 2001). The penetration rates of cars are 95% for young couples with children and 120% for older couples with children (CBS, 1995 in Kramer *et al.*, 1998). Households with one or two cars have significantly higher annual total energy requirements of 20 and 40 GJ, respectively, although this is also due to higher requirements for gas and electricity (Vringer *et al.*, 1997).

*Table 1 Energy use (direct + indirect) of different means of transport**

Means of transport	(MJ/pkm)	Means of transport	(MJ/pkm)
Car	4.06	Buses and city buses	1.87
Train	1.07	Bicycle	0.20
Touring car	0.53	Aircraft short distances	2.90
Boat	1.86	Aircraft long distances	2.39

** Kok et al., 2001*

1.3 Wash temperature

Most of the energy for washing (80-90%) is used for heating. This applies for an average cotton load of 4.5 kg washed at 60°C. The average washing temperature is ± 50°C. Temperatures above 60°C are basically no longer necessary, as the optimal washing temperature for white laundry is 60°C. Other laundry can be washed at 30-40°C, but, from an environmental point of view, preferably at 30°C. Lower temperatures are possible, thanks to better combinations of surfactants and bleach systems, and to the addition of enzymes. In industry, it is expected that developments in enzymes eventually can lead to ones that work optimally at 8°C. However, reducing to a wash temperature of 40°C seems more likely because the time needed for a cycle is comparable with what it is now. Such a time span is acceptable for households, and therefore the industry is aiming at developments towards the use of 40°C (Ybema, 1995; Ribhagen, 1997). Energy intensities of enzymes differ by a factor of 30, depending on the process control and on the state of genetic modification of the bacteria and fungi that produce enzymes. The energy intensity of commercially suitable enzymes is somewhere between 50 and 150 GJ/ton (Genecor, 1998; Ruttloff *et al.*, 1979). Enzymes in compact heavy-duty detergents account for 1%, in compact colour detergents for 2%, and in liquid heavy-duty detergents for 3% (Terpstra, 1997; Ribhagen, 1997; Uitdenbogerd, 1997). Not only lower temperatures are the result of using enzymes. With the use of lipase for example, the amount of surfactants (energy intensity around 63% GJ/ton) can be lowered by 10-20% (Ribhagen, 1997). As a consequence, less surfactants lead to less packaging and to fewer transport costs, and thus to a lower indirect e.r. to wash a kg of laundry. These developments in the industry took place, so the consumer now needs to follow these trends and wash more often at 40°C. Indeed, lower temperatures are only an improvement if the energy consumption of future detergents does not differ significantly. Until now this has not proven to be a problem. For example, although no figures exist yet regarding the energy intensity (e.i.) of super compact detergents, it is assumed that the e.i. is, at the most, 5% higher than that of normal detergents. In addition, the e.i. of normal detergents in Europe has decreased by at least one-third since the early 1990s, thanks to other composition processes (no spray dry towers) and to the compact forms, which saves packaging and transport energy. The use of detergents was therefore not thoroughly examined in the survey.

It is assumed that 1.5% enzymes are used per kg of detergent. With a recommended quantity of 70 grams of detergent, the use of enzymes accounts for 0.7% of the energy requirement for an average wash cycle (electricity + detergent). However, use of the detergent itself contributes to about 20- 50% of the energy requirement of a wash cycle (electricity + detergent), and this percentage is of course higher for lower temperatures. The amount of energy needed for enzymes is so low compared to what can be achieved in lowering wash temperatures, that the extra e.r. for enzymes can be ignored (Uitdenbogerd and Vringer, 1999).

Assuming that an average 10°C decrease in temperature will occur over the next five years, this will save 19% (Uitdenbogerd and Vringer, 1999). Although it cannot be expected that every household will lower by10°C, shifts in temperature classes could be possible.

Practices in changing temperatures in the past as well as in the future are examined in the survey, as it is expected that this might explain some of the acceptance of washing at lower temperatures. In addition, the use of, for instance, E-buttons (lower temperatures + extended wash time) is examined.

1.4 Use of appliances: washing machines, tumble dryers, freezers and fridges

Different usage of the washing machine relates to loading, frequency of use, and use of E-buttons.

- For loading: the average load reported by households lies between 3.7 and 4.3 kg. More quantitatively measured figures report 2.8 to 3.2 kg/load. Washing only with full loads (5 kg) instead of the average load (3.5 kg) will result in a reduction potential of 13% (0.5 MJ/kg laundry) (Uitdenbogerd and Vringer, 1999).
- Wash frequency will depend on loading and amount of laundry, which will depend on number of inhabitants, activities, wearing behaviour, decisions on laundering, and so forth. It is found that the amount of laundry per household per year increases in tandem with the growing number of persons per household. This might indicate that within larger households more activities take place that lead to relatively more laundry. Along with an increase in the number of persons per household, wash frequency increases and shows a gradually declining and more horizontal slope. These two facts indicate that larger households load more fully. The average washing frequency per year for an average household size of 2.34 persons is 159 for 3.5 kg loads (Uitdenbogerd and Vringer, 1999).
- Full loads with an unchanged amount of laundry lead to a lower washing frequency. For the case study, the degree of loading is expressed in terms of the average load in kg per wash cycle over all the washed cycles in the sample[34]. According to washing instructions, 95°C linen and cotton cycles can be loaded with 4-5 kg; likewise, 60°C cotton coloured articles; synthetics with 2.5 kg; wool; and fine

[34] Another calculation method would be to use the average load weight of cycles washed per household.

laundry with 1 kg. The theoretical maximal load can be calculated using this information. The first way to calculate the theoretical maximal load is to combine the wash advice with the occurrence of materials. About 57% of textiles sold in the Netherlands are of cotton, 28% of synthetics, and 15% of wool and cellulosic materials (FAO, 1994). Multiplying these percentages by the advised loads per material results in an average load of 3.7 kg (.57* 5 kg cotton and linen +.28*2.5 kg synthetics + 0.15*1 kg fine (wool + cellulosic)). The second method to calculate the theoretical maximal load is to multiply the advised load by the choice of washing machine programmes. In the SAVE II study on the revision of energy labelling for washing machines, it is estimated that in Europe 78.8% of the cycles are washed with cotton programmes, whereas easy-care programmes are used for 16.1% of the cycles and for 5.6% of wool and other programmes (SAVE II, 2001). The theoretical maximal load is then 4.4 kg (.788*5 cotton + .161*2.5 synthetics + .056*1 fine/wool). On the basis of these calculations, the theoretical maximum load is somewhere between 3.7 and 4.4 kg. It appears that the use of wash programmes does not coincide with the presence of textile materials. Perhaps cotton materials are used more often and therefore cotton wash programmes are chosen more frequently, but other explanations are possible as well. Given the incongruence of wash programmes and the presence of textile materials, it seems hardly possible to increase washing efficiency by increasing loads up to 5 kg. In addition, in practice it is difficult to fit 5 kg of laundry in the drum of a washing machine (Terpstra, 1996). Full loads are only possible when the machine is completely filled with large and heavy cotton pieces, such as folded sheets and jeans. The survey examined whether the practice of folding laundry was applied. Low loads can also be matched with a smaller washing machine, suitable for 3 kg (see 2.5 of this Appendix).

- The wash result is better when loads are lower: for instance, 4.7 kg compared with 2 kg (no significant differences between 4.7 kg and 3.7 kg; no significant differences in general between washing machines with and without a load-related water level). At it appears that folding 4.7 kg of laundry leads to a better wash result (no other load weights tested) (Harenberg *et al.*, 1999).
- Another likely determining factor of washing frequency is the amount of laundry, which will be determined by wearing and using behaviour. No literature exists about the relation between the wear and use frequency and the amount of laundry, so the practical wearing and using behaviour is investigated in the case study. Some first results are published in Uitdenbogerd *et al.* (1998).
- In the second half of the 1990s, the traditional colour detergents became 'Color' detergents. Some of the new upgraded 'Color' detergents claim that more colours can be washed in one load without colours running. This could lead to higher loads. The use of types of detergents and the influence of the 'Color' detergents is briefly examined in the case study.
- E-buttons change washing programmes to ones using lower temperatures and extended wash time. Estimated is a saving potential of 5 to 10%.
- The use of programmes is investigated in relation to sorting laundry, as the combination of programme use and sorting might influence a number of other energy indicators, such as wash frequency, wash temperature, and load weights. It is possible that options can be derived from this.

Different use characteristics related to the energy requirement of tumble dryers include loading, sorting and re-sorting laundry, and selective use, all of which are related to frequency of use.

- The amount of electricity used for drying one cotton cycle is almost twice the amount used for the washing. Consequently, the frequency of using the tumble dryer determines the total energy consumption to a greater extent than does the washing frequency. Although all the dirty laundry is washed in a machine, for a number of reasons not all the laundry is tumble dried. This leads to lower drying loads and drying frequency compared with wash loads and washing frequency. Lower loads can be inefficient but probably also take less energy than does a full drying load. It is assumed that a lower load takes as much energy as a full one. The average weight per load for dryers is 3.3 kg. Drying with only full loads rather than average loads results in an absolute increase in the energy requirement for drying and in a decrease in the relative energy requirement per kg: for 3.3-5 kg, a reduction of 10% per kg of laundry (0.6 MJ/kg) (Uitdenbogerd and Vringer, 1999).

- Selective use results in a lower drying frequency. Practices of re-sorting laundry and 'rules' for not drying all articles in the tumble dryer are not described in the literature. This information can be useful for laboratory research to determine the energy use of lower loads and loads with special materials. For instance, seasonal use and using the air-vented tumble dryer only during the six winter months would save 6% of the total annual energy requirement, including heating and ventilation.
- Another factor relating to frequency of dryer use could be the number of run lines from the washing machine to the place where laundry is hung to dry (convenience). Therefore, the location of washing machines, tumble dryers and places to line dry is investigated, used to determine run lines.

Use aspects related to the energy requirement of refrigerators and freezers, and to the possibility of changing to smaller appliances, are the size of stored or frozen stock, and the reduction herein.
In the event that one-third of Dutch households with a deep freezer replaces it with a two-door refrigerator, and another one-third gives up the freezer, savings regarding the household's lower stock of frozen products are then 16% of the energy requirement for storing (an ample 2% of the total food activity-related energy requirement) (Brouwer, 1998).

1.5 Pre-rinsing dishes

Based on Uitdenbogerd (1995), Nipo (1995) and Brouwer (1998) recalculated the energy requirement for dish washing. For washing by hand, on average 1873 MJ/hh.y is needed, whereas by using a dishwasher 725 MJ/hh.y is required (based on a penetration rate of ±20%): in total, 2600 MJ/hh.y. Households without a dish washing machine wash more frequently by hand and rinse more; 60 percent of Dutch households rinse the dishes. Eighty-four percent use warm water and 80% use a continuous flow of water (Nipo, 1995; Brouwer, 1998). The water use for rinsing is on average 6.1 litres per rinsing per household; ***warm*** water use is 1.6 litres/person.day. If all households stopped rinsing, or only rinsed with cold water, this could save each household 600 MJ per year (Brouwer, 1998).

2. Direct energy requirement, investments, or purchases

2.1 Energy-saving light bulbs

An average household spends about 13 euros per year on light bulbs and other lights. A normal 60 W bulb can be replaced by an energy-saving light bulb of 11 W. On average, a living-room lamp is used 1000 hours per year. Replacing normal bulbs therefore saves 505 MJ direct energy per lamp per year, or 81% per lamp per year (Kramer *et al.*, 1994). A normal light bulb costs less energy to produce but its lifetime is a factor of 5 shorter. A normal lamp bulb costs 3.8 MJ to produce and an energy-saving light bulb costs

81 MJ. An energy-saving light bulb also gives a little less light (lumen). Nevertheless, the efficiency of a normal bulb is 1 MJ/lumen-hour and of an energy-saving light bulb it is 0.26 MJ/lumen-hour (Potting *et al.*, 1995). The efficiency of the energy-saving light bulb is four times higher. However, at the end of its life an energy-saving light bulb is chemical waste.

2.2 Solar boiler

A standard solar boiler consists of a boiler and solar panels. The system is most often constructed to cover 50% of the energy need for heating warm water, and extra heating is provided by the normal system. The panels can be installed on a roof. Water that runs through the panels is heated by solar energy. On average, 50% of the energy needed for tap water heating can be saved, or 170-200 m^3 gas per household per year, about 50 euros per year and 6.4 GJ/hh.y (at 200 m^3 gas). This is for an average size of 2.5 m^2 and for a 100-litre boiler. Approximately 35,000 solar boilers were installed in the Netherlands in 1999 (Vademecum Water, 1999). There are also compact solar boilers that do not need a separate boiler; solar boilers with integrated boilers for the central heating water, which can be heated outside the boiler; and solar boilers with a combination of central heating for which the extra heating is integrated within the boiler. De Jager *et al.* (2002) calculated that a solar boiler system costs ± 4.5 GJ. In energy terms, this means that the solar boiler is a profitable choice. However, in money terms this is not the case, as gas savings of 15 years do not exceed the price, even including government subsidies (Janssen, 2003).

2.3 Green electricity

The use of electricity takes up approximately 12% of the total yearly energy requirement (both direct and indirect) (Biesiot and Moll, 1995). Depending on the energy company, green (or 'eco'; 'nature') electricity is generated by wind energy, solar energy, water power, bio-gas from land-fill sites, bio-mass, and so on. The use of green electricity does not save energy but it prevents the emission of greenhouse gases, such as CO_2 and CH_4. It was estimated that in 2002 20% of households in the Netherlands were using green electricity (Nuon, 2003).

2.4 Water-saving shower heads

Water-saving shower heads have more resistance, which leads to a smaller tap volume. The most economic ones have a pressure of about 3 bar, with a volume between 7.2 and 12 l/min. The savings in energy depend upon household size and composition (age of the members), showering behaviour, water pressure, type of shower head, heating system, length of pipes, and outside temperature. Groot-Marcus (1998) found the following:

Household characteristics

- People up to 35 years old shower 2 minutes longer compared with people older than 35 (7.6 min. vs. 5.3 min.), whereas the frequency is more or less equal (0.61 times/day);
- Members of larger families all shower for shorter periods;
- There are no differences between men and women, and the shower characteristics of family members are quite similar; thus, activities for water reduction focus best on households rather than individuals.

Interesting shower characteristics

- Washing one's hair results in an increase of 1 minute per shower (6.9 min. without vs. 7.8 min. with washing hair);
- A lower outside temperature (12º-19ºC compared with 20º-28ºC; mean difference of 10ºC) leads to a significant 0.5ºC increase in the water temperature (39.2º to 38.7ºC).

Related to water-saving shower heads

- A water-saving shower head leads to a 1.5ºC increase (from 38.2º to 39.7ºC) in water temperature;
- The duration of showers using normal and water-saving shower heads is not significantly different; thus, savings can also in practice be attributed to the diminishing of the water flow;
- The difference in water use between normal and water-saving shower heads is smaller for heating systems with a boiler compared with combi-systems, as households with a boiler shower for shorter periods (8.5 minutes vs. 7.3 minutes);
- The shower frequency of household members with water-saving shower heads is higher compared with households with normal shower heads (9.9 times per 2 weeks vs. 6.7; or 0.71/day vs. 0.48),

In addition, there are, for example, shower heads with rubber rings, and for which the volume is not related to water pressure, which influences possible savings (Vademecum Water, 1999). Also, for normal shower heads the full flow capacity is seldom used (Groot-Marcus *et al.*, 1995). Taking into account frequency and volume flow, households with a normal shower head use 22 litres water per person per day; households with a water-saving shower head use 18 litres per person per day (Groot-Marcus *et al.*, 1995). This means that the absolute saving potential is not as large as assumed. It is generally assumed that approximately 40 litres water are needed for showering, per person per day. Approximately 375 m^3 gas is needed for water heating per household per year, of which half is used for showering (Vademecum Water, 1999). A water-saving shower head saves 20-30% (Vademecum Water, 1999; Groot-Marcus, 1998). Savings per household are then ca. 10 m^3 water, 40-45 m^3 gas, and 20-25 euros per year (Vademecum Water, 1999). Using a water-saving shower head reduces the energy requirement from 12.1 MJ/shower to 9.0 MJ/shower (Groot-Marcus, 1998). In total, it saves roughly 1.3-1.6 GJ/household.year.

2.5 Alternatives for appliances

With regard to washing machines, alternatives could include using smaller washing machines to match the average load, using the most efficient washing machine, and using hot-fill machines.

- A smaller washing machine, to match the average load of 3.5 kg, can save 10% per kg of laundry, on the basis that it is fully loaded, and in comparison with a normal washing machine that is not fully loaded (Uitdenbogerd and Vringer, 1999). It can be questioned whether in practice the load will be lower (e.g. 2.5 kg at the most). In that case, the expected practical result is an increase in energy use per kg of laundry instead of a decrease. The practices of loading normal washing machines and hypothetical small washing machines are examined in the survey.
- The most efficient washing machines on the market require 20% less (direct) energy than do the washing machines currently used by households. This is a reduction of 12% (0.5 MJ/kg) in the total energy requirement for washing (including water, detergents and indirect e.r. for the washing

machine). Most washing machines will reach last for 10-12 years. The average energy efficiency improvement is approximately 1% per year (Uitdenbogerd and Vringer, 1999).

- The primary energy use of washing machines can be lowered by substituting electricity for water heating by other energy or heat sources, such as a gas-fired central heating system or a gas-fired warm tap-water system. Hot-fill machines or machines connected to the central heating system have been developed for this purpose, and can lead to a reduction of about 14% in the direct primary energy needed for a 60ºC cycle (0.5 MJ/kg). However, the saving potential in percentages depends on the washing temperature and the efficiency of the warm-water supply (Uitdenbogerd and Vringer, 1999). Taking the heat loss of the water distribution system into account, the efficiency could be even less. Moreover, a structural problem diminishes the potential of using these machines: in the Netherlands most of the built-in supplying taps for washing machines only have cold water. Hot-fill machines were already a topic of discussion in the early 1980s (Konings et al., 1984), but they have still not increased significantly in households. Because of the tap problem, it is unlikely that this will change in the near future, as this structural problem will only be resolved slowly in new housing projects. However, the main reason not to include these appliances in the survey is that it is expected they have no impact on household use patterns, and that the acceptability of hot-fill machines will not be influenced by any necessary changes in use. An increase in the stock of these appliances will depend mainly on structural provisions.

Other appliance-related options involve sharing the use of appliances, having a lifetime extension, and not having a washing machine but farming out the laundry. These options are not examined in the survey, as the gains of the first two options are minor and the third costs even more energy (Uitdenbogerd and Vringer, 1999).

Alternatives for tumble dryers include gas-fired dryers, using the most efficient tumble dryer, increasing spin capacity to reduce the rest humidity of fresh washed laundry, and not buying or replacing the tumble dryer, possibly in combination with having extra space for line drying.

- A gas-fired dryer under user conditions can save up to 23% compared with the average dryer in stock under current user conditions. Cost-efficiency is related to frequency of use: The more it is used, the more cost-efficient it is. Gas-fired dryers are air-vented. In comparison with condensation dryers in stock, a gas-fired dryer saves 46% for standardised loads. This appliance influences usage (quicker, safety concerns, pay-back time related to frequency of use).
- Different references give varying estimates of the difference between the most efficient tumble dryer and the tumble dryers in stock. According to Kemna *et al.* (1995), the best tumble dryers on the market were 30% more efficient compared with the machines in household stock. According to EnergieNed (Weegink, 1997), the best machines on the market were 10% more efficient compared with those in household stock. It is assumed that there is an energy efficiency improvement of 20% (1.1 MJ/kg) for the most efficient dryers compared with those in a household's stock (Uitdenbogerd and Vringer, 1999).
- Selective use of dryers (not in the summer, etc.) can also reduce energy use. A factor in selective use could, for example, be the spinning capacity of either the washing machine or the spinner. A low spinning capacity results in articles with a relatively high moisture content, which will take longer to line dry, perhaps leading to more frequent tumble drying. In addition, these articles take more energy

to tumble dry. A saving of 1.0 MJ/kg is achieved if laundry is spin-dried up to a rest humidity of 50% instead of the average 60%. In the Netherlands, the average rpm (rotations per minute) for spinning is more than 1100 rpm (GEA, 1995). The residual moisture content of cotton that is spin-dried at 1100-1200 rpm is around 60%. It could need a shift to 1300 rpm to achieve a residual moisture content of 50% (GEA, I, 10, p.13). Compared with the rest of Europe (877), the Netherlands has a relatively high average spin-dry speed. An assumption made in the GEA background report 10 (I, 10, p.13, 1995) is that within 50 years the average spin-dry speed will double from 700 to 1400 rpm by 2016, resulting in an approximate 25% energy reduction for drying since the 1970s. In accordance with the assumption, without extra measures it would take 14 years for all Dutch laundry to be spin-dried up to a residual moisture content of 50%. A high spinning capacity in itself can reduce 10-15% of the energy needed for drying. The extra energy requirement for the higher spin rate or better components of the washing machine is negligible (Shephard *et al.*, 1990).

- The purchase of a tumble dryer could be influenced by the available space to line dry, as many households with a dryer expressed having difficulties with too little space (Aarts, 1995). Line drying saves nearly 91% of the energy needed to tumble dry a cycle (Uitdenbogerd and Vringer, 1999). Little energy for line drying is needed for evaporation and ventilation, for instance. Although extra space for line drying costs energy, drying space could replace a tumble dryer. The option of extra space is therefore examined in the survey. Not buying a tumble dryer or not replacing one is equal to drying all the laundry on clotheslines, which saves 89% of the direct e.r. of the drying phase; an extra saving is then the indirect energy requirement for the dryer itself, which is 0.7 MJ/kg (nearly 7% of the total average e.r. for laundering and 11% of the drying phase [both direct and indirect e.r.]). Laundry that is not tumble dried needs clotheslines and space. In total, a minimum surface of 3.4 m^2 is needed for a washing machine and for sufficient clotheslines, and 1.2 m^2 is extra for more lines (based on VAC, 1997). One m^2 of living space requires 0.14 GJ/y. Additional space just for line drying (1.2 m^2) therefore costs 168 MJ/y or 0.2 MJ/kg of laundry. Together, the combined options of line drying and extra space save 76% compared with the average current laundering and drying process (Uitdenbogerd and Vringer, 1999).

Alternatives for refrigerators include using the most energy-efficient ones, buying smaller ones, and using a cellar (to reduce stock in the refrigerator as well as to have the refrigerator placed in a cool environment). Alternatives for freezers involve using the most energy-efficient ones, buying smaller ones, placing it in a cool cellar, and not replacing it.

- The most efficient freezers are 10- 20% more energy-friendly compared with the freezers in stock.
- If households with a deep freezer (penetration rate 56%) replace it (and their refrigerator without a freezing compartment; penetration rate 30%) with a two-door fridge or freezer, it can result in an energy reduction of 24%.
- Placement of a refrigerator or freezer in the cellar (penetration rate 9%) instead of the kitchen reduces the energy requirement for cooling and freezing. Because the loss of heat for refrigerators is proportional to the temperature difference between inside and outside the appliance, the savings are different for cooling and freezing. Placing the refrigerator in the cellar can save 67%; placing the freezer in the cellar can save 27%.

- If households with a freezer (penetration rate of 56%) get rid of it and only use the freezing compartment that is already present in their refrigerator, it can save 35% of the energy required for cooling and freezing (Brouwer, 1998).

3. Indirect energy requirement and changes in use and practices

3.1 Leisure activities (holidays and transport)

Leisure activities count for 18% (42 of 240 GJ/y) of the total energy requirement for a household, and can take place indoors or outdoors. In fact, a distribution can be made of leisure activities indoors, outdoors within the country, and holidays abroad. See Table 2C.2 for a related summary of the expenditures, time, and energy requirements. Of the 12 GJ for holidays, 15% is required for accommodation and 85% for transport. The energy intensity for weekend activities is 2.9 MJ/euros, for holidays within the Netherlands 2.9 MJ/euros and for travel outside the country 3.4 MJ/euros (Kok *et al.*, 2001). The energy intensity in MJ/hour varies more strongly than in MJ/euros. For holidays it is > 20 MJ/hour, for outdoor activities 10 MJ/hour, and for indoor activities < 5 MJ/hour.

It is interesting to investigate reduction options for leisure activities (van den Berg and Vringer, 1999), as holidays have the highest energy intensity per hour (MJ/hour).

Table 2 Financial and time expenditure and the energy requirement of an average Dutch household in 1990

Per household	Time (hours)	Time (%)	Expenditures (euros)	Expenditures (%)	Energy (GJ)	Energy (%)
Total	19.272		18230		240	
Leisure	5.500		3500		42	
Indoors	3.300	17	1272	7	13	5
Outdoors	1.600	8	1318	7	17	7
Holidays	600	3	909	5	12	5

van den Berg and Vringer, 1999; MJ/gld converted to MJ/euro, 2.2 gld = 1 euro

Aspects that influence the e.r. of holidays are destination, means of transport, accommodation, expenditures, and duration. The total holiday participation of Dutch inhabitants in 1995 was 77%. Of all holiday expenditures, 78% was spent abroad. The favourite means of transport for holidays are the car followed by the airplane, the popularity of which is increasing. The top three destinations are France, Spain, and Germany. Accommodation abroad is equally divided (each 20%) over hotels, apartments, tents, and caravans. A remaining category of 20% consists of 'stay at relatives', friends', youth hostels, sailing boats, second homes, and so on.

*Table 3 Energy requirement of different forms of accommodation**

	Winter (MJ/visitor/day)	Summer (MJ/visitor/day)
Hotel	355	501
Apartment	92.5	215
Caravan	72	72
Tent	48	48
Boat	13	13

**De Paauw, 1995; Imming et al., 1995 in: Kok et al., 2001*

Reduction options defined for the general survey are spending a holiday closer to home, less often but longer and further, including use of a tent instead of a cottage or apartment, and so forth. Staying in a tent rather than in a hotel will save approximately 0.5% of households' total energy consumption (Wilting *et al.*, 1999).

Halving the distance for holidays affects expenditures on motor fuels, car repairs, rail services, and air services, and, depending on the destination, saves between 26 and 47% (van den Berg and Vringer, 1999).

Table 4 Relative energy requirement of various means of transport in MJ per person kilometre (MJ/pkm)

Transport	(MJ/pkm)	Transport	(MJ/pkm)
Car 2 persons	1.94	Plane (Boeing 737-400 for 3000 km)	2.08
Car 4 persons	0.97		
Coach	0.56	Plane (Boeing 747)	1.91
International train	0.94	Regional bus	1.87

van den Berg and Vringer, 1999

As it is not possible to design an 'average' holiday, nine standard packages are defined, each representing a large group of Dutch vacationers during their long summer holidays.

Table 5 Energy requirement (e.r.) of nine holiday packages and the percentage of Dutch households reflected by each package

%hh	Destination	Return (km)	Transport	Duration (days)	Tour party	E.r. pp per holiday (GJ)	E.r. pp per day (GJ)
23	No holiday	-	-	-	-	-	-
35	Vlissingen B	500	Car	7	4	1	0.1
9	Chamonix H	2040	Car	14	2	6	0.5
6	Antibes T	2800	Car	21	4	4	0.2
3	Tenerife H	6000	Plane	7	2	14	2.0
7	Barcelona B	3200	Coach	14	2	4	0.3
5	Trier H	800	Car	14	2	4	0.3
4	Siegen B	700	Train	7	4	2	0.2
3	Jakarta H	24000	Plane	14	2	49	3.5
4	Los Angeles H	18000	Plane	14	2	37	2.6

Nonhebel and Moll, 2001; van den Berg and Vringer, 1999; H=hotel, B=bungalow, T=tent

The total costs per person per holiday are around 290 euros or 25 euros per day. The energy intensity is 3.6 MJ/euros and the average e.r. per holiday is 5.1 GJ. The e.r. of the nine holiday packages largely vary, mainly due to differences in the distance travelled and not to the means of transport or type of accommodation.

When combining the given percentages, assuming that these indeed represent their share of the Dutch population, it can be concluded that households that go on a long-distance holiday (7%) consume nearly 60% of the total energy used by households during a vacation. However, almost 60% of households (23% that do not go on a holiday and 35% that take a holiday in the Netherlands) consume only 7% of the total e.r. This points to a striking unbalance in the energy requirement of different households for holiday purposes (van den Berg and Vringer, 1999).

If the distances travelled were reduced by 50% and all nights were spent in a tent, the average household e.r. would be 6.1 GJ, a reduction of more than 50%.

3.2 Longer use of textiles

The use of textiles determines the amount of laundry, which again influences washing frequency. Washing frequency has risen since the 1950s and the amount of laundry has increased from 4.2 kg per household in 1950 to 16.5 kg in 1994, although the average household size had decreased from 4.2 to 2.4 persons. In other words, the amount of laundry per person had increased by a factor of 6.7. This looks like a shift from changing clothes once a week to changing clothes every day. Undoubtedly there will be a variation in this, which offers possibilities for energy saving. Every load not washed saves around 9 MJ (approx. 1 kWh).

3.3 Alternatives for textile materials

Textiles and textile maintenance make up an important part of the household resource demand. An average Dutch household spends 1135 euros/year (6% of the annual budget) and 7 hours per week on clothing and textile purchases and on maintenance. Households purchase about 15 kg of textiles annually, 70% of which is made of cotton and the remainder consists of synthetics and wool. Due to losses in the production chain, 18 kg of textile fibres have to be produced for the production of 15 kg of household textiles. The energy requirements for the production of various types of fibres are also given: The natural materials wool and cotton display the lowest energy requirements, whereas the energy requirements of the synthetic fibres is nearly 3 times as high as energy requirements for wool and cotton. The energy used in fibre production is small (23%) in comparison with the requirements in the rest of the chain: spinning, knitting, finishing, confection, transport, wholesale, and retail. Energy requirements in the rest of the chain (from spinning to retail) are independent of the fibre type. This implies that the choice of materials has only a small effect on the total energy requirement for the production of textile materials.

Table 6 Energy requirements (e.r.) in different stages of the life cycle of clothes, expressed in percentages of the total energy requirement

Stage life cycle	E.r. (% of total)	Stage life cycle	E.r. (% of total)
1. Fibre production	23	5. Knitting	4
2. Wholesale trade	1	6. Spinning	4
3. Retail trade	45	7. Textile finishing	14
4. Transport	4	8. Confection	7

Potting and Blok, 2000

Furthermore, most of the fibres consist of cotton, with a relatively low energy requirement. A shift to other fibres will imply a relatively small increase in energy use for the production of textile materials.

Table 7 Energy requirement (e.r.) to produce the most frequently used fibres per kg and average annual quantities of textile materials bought per household, resulting in the e.r. for textiles per household per year

Material	Bought kg/hh.y	E.r. (MJ/kg fibre)	Total e.r (MJ/hh.y)	Material	Bought kg/hh.y	E.r. (MJ/kg fibre)	Total e.r (MJ/hh.y)
Cotton	12.7	50	635	Polyester	2.37	93	220
Polyacryl	0.43	136	58	Viscose	0.89	151	134
Polyamide	1.04	130	135	Wool	1.21	16	19

Potting and Blok, 2000

The use of cellulosic and synthetic materials, which have energy intensities that are a little higher, has declined since the 1970s (FAO, 1994) and is still decreasing in favour of cotton. Nevertheless, different textile materials have an effect on the maintenance practices within households, with consequences for the energy requirement. For textile materials, only how materials 'behave' in the wearing and maintenance situation was examined. Alternatives to be examined are wool (for jumpers) and blends of cotton/polyester for bedding.

- Besides the fact that wool costs less indirect energy per kg fibre, it has three advantages in use, related to warmth, dirt, and wash temperature. Firstly, woollen jumpers provide extra warmth, and savings can be achieved by lowering room temperatures, about 3% of the energy needed for space heating. This is 15% of the total energy needed for the entire activity category Textiles. It can be assumed that extra woollen clothing can compensate for 1-2°C heating (based on McIntryre and Griffiths, 1975). Secondly, wool can be worn longer than cotton because of the fibre attributes (less dirt is attracted), which results in less laundry. Thirdly, wool needs to be washed at low temperatures and cannot be tumble dried. The possible extra woollen items needed and the lower loading of washing machines can increase the energy required for washing. This does not equal the savings achieved by heating less (see Uitdenbogerd and Vringer, 1999). However, wool is associated with high emissions of greenhouse gasses (as the sheep produce methane when they digest grass), so synthetic alternatives for wool with high insulation capacities might have an even more positive reduction potential with relation to room heating.
- The energy requirement to wash and dry synthetic textile differs from the energy use to wash and dry cotton textiles. This is due to differences between the washing and drying programmes and the maximum load. Moreover, synthetic fibres absorb less water than do cotton fibres, and lower washing temperatures are required. Both aspects could lead to the formulation of reduction options (Uitdenbogerd and Vringer, 1999):
- The relative energy requirement for washing 1 kg of synthetic textile at 60°C is about 1.7 times higher than for washing 1 kg of cotton textile at 60°C. The higher direct energy requirement per kg is due to the lower maximum load per cycle. Using standard test methods, almost no difference in energy use was seen for washing cotton at 60°C and synthetics at 40°C.
- The average users' situation consists of washing 3.5 kg cotton textiles at 50°C and drying 3.3 kg with average appliances in stock, leading to an energy requirement of 10.3 MJ/kg.
- The least optimal situation exists when the condenser dryer in stock (5.7 MJ/kg) is coupled with washing synthetics at 60ºC with washing machines in stock; this costs 11.3 MJ/kg, 9% more than the average users' e.r. (10.3 MJ/kg).
- The most energy-friendly combination is washing cotton at 40°C using the best appliances on the market, with a residual moisture content of 50%, and drying the load with an air-vented tumble dryer (6.1MJ/kg). It can be concluded that, in particular, washing at 40°C and using a gas-fired dryer makes a difference. It can also be inferred that synthetics make a bigger difference for drying than for washing.
- The combination of washing synthetics the same way as cotton and drying them with a synthetic programme (preferably with a gas-fired dryer) is a reduction option worth aiming for. In contrast to cotton programmes, the synthetic wash programme is not often used in the Netherlands. Synthetic materials are often applied in blends with cotton (e.g. polyester/cotton blends of 35/65 or 45/55). Probably these blends are treated as cotton laundry. Therefore it is expected that blends for cotton/polyester bedding can be washed in normal cotton loads, whereas less energy for tumble drying is needed. Blends of cotton/polyester, or the use of 100% (polyester), lead in the best market situation, and wash temperatures of 40°C lead to a slight reduction for washing (0.2 MJ/kg) and for drying (1.5 MJ/kg) compared with the present situation.
- However, it appears that the differences between cotton and cotton/polyester are not as large as between cotton towelling or CO/PE towelling. Water and energy use per kg of textile increases when

the loads are lower and the material is more absorbent, and when machines without a load-related water level are used (Harenberg *et al.*, 1999).

4. Indirect energy requirement, investments or purchases

4.1 Floor covering

Natural floor coverings (wool, wood, cork, linoleum, stone paving, laminate, carpet with a back of burlap) are roughly up to 4 times energy friendlier than synthetic materials, such as vinyl and wall- to-wall polyamide carpets (Potting *and* Blok, 1994). Four-metre-wide rolls of polyamide cost around 106 MJ/m^2, cotton rolls around 92 MJ/m^2 and woollen rolls 24 MJ/m^2. Vinyl costs around 102 MJ/m^2, whereas linoleum costs 40 MJ/m^2 (Potting *et al.*, 1995). Burlap backing costs around 16 MJ/m^2, PP 24 MJ/m^2 and foam 34 MJ/m^2. Although it has decreased in popularity since the 1970s, polyamide wall-to-wall carpets make up the largest percentage of floor coverings (±40%).

4.2 Flowers and gifts

In the Netherlands, cut flowers are used as household decoration and also play an important role as gifts. Energy requirement for flowers and plants is 1% of the yearly total e.r. of a household (2.2 GJ/hh.y). The energy intensity for flowers (± 6 MJ/euro) is one of the highest compared with other products and services (Vringer and Blok, 2000). The energy requirements of 37 of the most common flowers grown in the Netherlands are determined. The variation in e.r. is considerable: from 2 MJ/flower for a monkshood to 200 MJ/flower for a flamingo flower. The main reason turned out to be the heating of greenhouses. Flowers grown outdoors have a lower e.r. than those grown in greenhouses. The heating requirements differ per season and therefore attention was given to the e.r. of cut flowers when they were grown in different seasons. The variation implies that the e.r. of a bouquet of flowers depends on the type of flower in the bouquet and the time of year in which the bouquet is bought. For instance, in increasing order, tulips (<5 MJ/flower), freesias (12 MJ/flower), roses (19 MJ/flower), and chrysanthemums (26 MJ/flower) use more energy in winter than in summer (5-12 MJ/flower).

Energy-friendly alternatives to flowers are pot-plants, ecologically grown flowers, music or film CDs or DVDs, book coupons, or other gifts, such as sweets, wine or spirits, and fruit juices. In 1990, an average Dutch household purchased 11 times one or more bouquets, containing a total of 250 flowers. Flowers represent about 30% of the smaller gifts, and about 50% of all flowers are purchased as presents. The other 50% is used for decoration. The question is how often can bouquets, gift or not, be replaced with the alternatives. It can be assumed that there is a potential of 50% (1.1 GJ/hh.y).

4.3 Meat

Various types of meat and meat products differ in energy requirements and greenhouse gas emissions. For example, reducing beef consumption by 50% in favour of 25% pork and 25% chicken saves 207 MJ/hh.y (Kramer, 1998). This is 5% of the yearly energy requirement for meat. Energy can also be saved by consuming a lower amount of meat per day. In the Netherlands, meat consumption is 11% higher than is recommended by nutrition experts. Consuming the advised amount saves 510 MJ/hh.y. Another reduction option is to eat a vegetarian meal instead of one with meat. Pulses and cheese save 95 and 30% energy, respectively.

4.4 Vegetables

On a national scale, pre-frozen, greenhouse, and imported vegetables involve two to four times more energy than those grown in the soil on open ground (seasonal vegetables) (Kok, Biesiot and Wilting, 1993; Uitdenbogerd, 1995). In addition, vegetables that were grown in soil and then conserved are more energy-friendly than pre-frozen, greenhouse, or imported vegetables. Of the household expenditures on food, approximately 8.8% is spent on vegetables, 2% of which goes on conserved vegetables (dried, glass, tins) and 0.8% on frozen vegetables. Of the 30 GJ indirect energy needed for food products, 15% is spent on vegetables (4.7 GJ/hh.y). More than half (58%) of the energy requirement for vegetables is related to vegetables grown in greenhouses (Kramer, 1998a). For the category Vegetables, replacing frozen, greenhouse, and imported vegetables with the home-grown variety can give a reduction of up to 4% of the e.r. (Kramer, 1998a). Depending on the type of vegetable (e.g. spinach or carrots), replacing greenhouse, imported, or frozen versions with vegetables grown in soil and then conserved in glass can save between 40 and 70%.

Appendix 3A Mental accounting and diffusion of innovations

To switch household behaviour to an environmentally friendly direction, several changes have to be made. To structure these, a search for clusters of activities or of expenditure categories was made, using factor analysis. Often the items within factors show activities within domains, and the factors contain activities that have different patterns of occurrence and levels of difficulty (Steg, 1999; Uneken, 1999; Uusitalo in: Joerges, 1982). Antonides *et al.* (1996) tried a new approach. The core idea in Mental Accounting is that people form mental categories of activities, expenditures and so on, and segregated losses and profits are valued much higher than are integrated losses and profits of the same magnitude. For energy-saving measures to succeed, the knowledge about which energy-saving behaviours are segregated and integrated in different categories, and the relative costs and profits of changing these behaviours, is relevant for energy policy makers.

Antonides interviewed consumers to establish which products, services, and behaviours they associated with energy and how they categorised these behaviours, including the effort it took to save energy in those categories. It was concluded that the respondents indeed applied mental accounting. Six clusters of energy-related behaviour in three dimensions (inside and outside; travel for work and in one's free time; infrequent and repeated behaviours) were found. Respondents had more difficulty applying more energy-saving activities between categories than within categories; the number of categories did not influence the experienced difficulty; and when people's behaviour was already energy-sound it increased the difficulty of making this behaviour or the category of behaviour more energy sound. However, the scope of activities in Antonides' research was wide, and the activities were formulated from an energy perspective. It is likely that mental accounting is also present on a smaller scale, when more differentiated daily activities are investigated from a household perspective.

The acceptance of changes by the public and by the individual in a social setting is described by Rogers (1995). *Diffusion* is the process whereby an innovation (1), is communicated by means of channels (2), in a certain time (3), and among members of a social system (4). Rogers uses the term *adoption* for the final decision to continue full use of an innovation. The *adoption process* is the mental process through which an individual passes from first hearing about an innovation to the final adoption. The adoption rate is the relative speed with which an innovation is adopted. *Innovativeness* is the degree to which an individual is relatively early in adopting new ideas as compared with other members of his social system. Rogers describes five phases in the decision-making process: knowledge, attitude, decision-making, implementation, and confirmation. He also describes five stages in the adoption process: awareness, interest, evaluation, trial, and adoption. Other theories lack a sort of short-circuit realisation (the *Aha* experience) that an environmentally friendly solution is applicable to one's own situation. This specific element is present in Rogers' 'interest' stage. Five adoption categories are distinguished: the innovators (2.5%); the early adopters (13.5%) who form the early market; the early majority (34%); the late majority (34%); and the laggards (16%) who form the mainstream market (Rogers, 1995; Moore, 2000). In general, the five categories have different characteristics. Furthermore, five factors influence the adoption-rate: relative advantage, suitability, complexity, triability and visibility of the innovation. Moore describes a chasm between the early market and the mainstream market, especially between the groups of early adopters and the early majority. He promotes a segmenting solution, which involves concentrating on small groups in the early majority markets. After initial adoption, reinvention can occur. Reasons for reinvention can be the need for more simplicity or opportunities for flexible application for the solution of diverse problems.

Appendix 4A Methods of analyses

Analyses used in Chapter 4 and 5 included the following methods (based on Norusis, 1990; Schreuder, 1991; Huizingh, 1999):

- Correlation analyses; whereby a variable is correlated with the other variables in the survey. Where applicable, the sample was split into households that own a dryer and those that do not. Chi² (χ^2) and Kendal's tau-c (τ_c) are used. Chi² is a symmetrical measure for nominal variables. Kendal's tau-c is a symmetrical measure for ordinal variables with unequal numbers of answer categories. Using Kendal's tau-c means some loss of information when used for ratio or interval variables. Also an asymmetrical measure such as Eta could be used, using ratio variables, such as wash frequency, as dependent variables. However, it is sufficient to examine the relation without assumptions about the direction of the relation. The choice between Spearman's rho or Kendal's tau, which are both symmetrical and suitable for ordinal variables, is based on the assumption that Kendal's tau-c performs better because it corrects for knots and the possibility to use it for variables with unequal numbers of answer categories. The characteristics of the Kendal's tau-c measure make it possible to examine all relations with the same measure, which simplifies comparison of correlation strengths;
- One-way variance analyses with Tukey HSD were used in Chapter 4 to test whether differences between category averages are significant. Variance analyses are suitable for variables with a nominal independent variable. Instead of a linear line, as in regression analyses, the path of averages is used. For each category of the independent variable, the average score on the dependent variable is

calculated. The more the averages differ, the stronger the effect of the dependent variable. The variance of the category averages compared with the total variance is the explained variance, which is used to investigate the relations between behaviours and the responses to related reduction options;

- In Chapter 5, one-way Anova with a post hoc multiple comparison test was also used (Scheffé) to pinpoint where the means differences are. The Scheffé method is conservative for pair-wise comparisons of means. It requires larger differences between means for significance than most of the other methods, to compensate for the larger chance on significant differences when more groups are compared;
- Scales were built, mostly by adding, of items that measure the same concept as the scale itself intends. To test whether variables could form a scale to measure a concept, reliability analysis was applied. Cronbach's alpha tests the internal consistency of scale items, based on the average correlation between items when they are standardised to a standard deviation of 1. Alpha ranges from 0 (low reliability) to 1 (high reliability);
- Cluster analysis was applied to find and identify homogeneous groups of clusters of households with similar habits. By studying the clusters, it can be determined which characteristics are shared by the cases and which differ. Clustering of cases is based on nearest centroid sorting. A case is assigned to the cluster for which the distance between the case and the centre of the cluster (centroid) is smallest;
- To test whether a variable is normally distributed, the Kolmogorov Smirnov Goodness of Fit Test was used. It uses the differences between theoretical and measured cumulative frequencies per category. The larger the largest difference, the less likely it is that the distribution is normal. It was used to compare the distribution of the sample with national statistics;
- Multiple regression analyses were performed to find out how much of the variation is determined by which of the independent variables. In Chapter 4 the stepwise method was used, in Chapter 5 the enter method was used iteratively while the non-significant itmes were withdrawn. Missings were mean substituted. For the stepwise method, two levels of significance are used for variables that add to the explained variation (R^2): one to enter variables and one to remove variables. Both methods lead to the smallest possible set of variables with the highest explaining effect;
- Factor analyses were done to reduce the number of variables that give more or less the same information. Factor analysis is based on spurious correlations between variables. The Kaiser-Meyer-Olkin measure is an index for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. The principle component analysis (PCA), which makes linear combinations of variables that are uncorrelated with each other, is applied. Varimax rotation is used, which attempts to minimize the number of variables that have high loadings on a factor. This enhances the interpretability of the factors. Varimax rotation results in orthogonal, uncorrelated factors.

Appendix 4B Case-study questionnaire (1997)

Answered by the interviewer:

AA001 ...	Household number
AA002 ...	Town
AA003 ...	Starting time
AA004 ...	Finishing time
AA005 ...	Method of recruitment

A001 What is the sex of the respondent?

0	male	8%
1	female	92%

A002 In what type of dwelling does the respondent live?

1	detached/semi-detached	24%
2	terraced house	60%
3	apartment	12%
4	other	4%

Answered by the respondent:

How many children do you have?

A003	living at home	100% of the households, on average 2.21
A004	living away from home	12% of the households, on average 0.15

Are there any other lodgers or residents?

A005	0	no 4%	1	yes 96%	Partner
A006	0	no 97%	1	yes 3%	Others

A007 .. total number of persons living in the house (A003+A005+A006)
on average 4.20 persons

What is the age of

A008	the respondent?	Average 39.85	(n=104)
A009	the partner?	Average 41.15	(n=100)
A010	the eldest child	Average 11.81	(n=104)
A011	the second child	Average 10.14	(n=88)
A012	the third child	Average 9.54	(n=39)
A013	the fourth child a	Average 9.67	(n=12)
A014	the fifth child	Average 13.00	(n=2)
A015	the sixth child	Average 3.00	(n=1)

A016 Who is the breadwinner?

0	respondent	13%
1	partner	78%

	2	both	9%

A017	What is the highest education level of the respondent?		
A018	What is the highest education level of the partner?		
	1	primary school	4% / -
	2	lower vocational education	14%/23%
	3	middle general education	16%/9%
	4	middle vocational education	16%/14%
	5	higher general education	6%/3%
	6	higher vocational education	26%/24%
	7	university or polytechnic	16%/27%

Do you have a paid job?

A020	0	no 36% 1	yes 64%
A021	..	hours/week	average 14.4 hours
A022	..	profession	

Does your partner have a paid job?

A023	0	no -	1 yes 100%
A024	..	hours/week	average 37.6 hours
A025	..	profession	

Apart from working hours, how many hours are spent outside the house for travelling and obligations?

A026	..	respondent	average 4.46
A027	..	partner	average 5.86

A028	What is the monthly net income of the household?			
	1	less than *f*2000.-	4%	no answer 11%
	2	*f*2000.- to 3500.-	21%	
	3	*f*3500.- to 5000.-	29%	
	4	*f*5000.- to 6500.-	19%	
	5	*f*6500.- to 8000.-	9%	
	6	*f*8000.- to 9500.-	3%	
	7	*f*9500.- or more.-	4%	

A029	Are you religious?		
	0	no	61%
	1	yes, but not practising	12%
	2	yes	27%

A030	Do you own the house or is it rented?			
	0	rented 31%	1	property 69%
A031	How many rooms are in the house (including living and bedrooms)?			

.. rooms average 5.03 rooms

A032 What is the total length of the hanging rods used for clothes hangers?

.. metres average 3.29 metres

Who takes care of the laundry?		Never	Sometimes	Mostly
A033	respondent	0 1%	1 7%	2 92%
A034	partner	0 61%	1 30%	2 9%
A035	home help	0 96%	1 2%	2 2%
A036	others	0 90%	1 9%	2 1%

Who takes care of the food/cooking?		Never	Sometimes	Mostly
A037	respondent	0 1%	1 13%	2 86%
A038	partner	0 38%	1 48%	2 14%
A039	home help	0 99%	1 1%	2 --
A040	others	0 81%	1 19%	2 --

A041 Do you participate in 'Actie Natuurstroom' or 'Green Electricity' or are you familiar with these programmes?

1	I am not familiar with these programmes	59%
2	no	33%
3	yes	8%

Do you...		Always 3	Regularly 2	Sometimes 1	Hardly/never 0
A042	close the curtains at night?	3 69%	2 17%	1 3%	0 11%
A043	buy eco-labelled products?	3 4%	2 25%	1 42%	0 29%
A044	separate waste?	3 84%	2 8%	1 4%	0 4%

Do you...		No 0	Yes 1	Do not know 7
A045	use a economy shower head	0 45%	1 48%	7 7%
A046	use energy-saving light bulbs	0 37%	1 63%	7 --

Imagine that you do not have the time or the opportunity to take care of the household for a couple of weeks. What changes in cooking and what kind of solutions do you apply (e.g. conserved vegetables, salads, bread and eggs, convenience food, quick recipes, someone else cooks, take-away food)?

A047 Open question; no change 7%, change 93%

What changes in the textile maintenance (e.g. quickly while doing other activities, everything in one load, ask someone else, no washing by hand, no ironing, postponing)? (more than one answer possible)

A048 Open question; no change 11%, change 89%

- change in who launders (someone familiar in or outside the household)	56%
- change in how laundering is carried out (skip ironing)	14%
- change in when it is done (postpone; in the evenings; quicker in between)	33%

- change in amounts of laundry (check carefully, use clothes and bedding longer)	12%
- laundry will just mount up, sufficient stock, wash later more often	13%
- no change, laundering continues, less other household tasks	11%

The questionnaire continues with questions about clothing, textiles and textile maintenance.

		0 never	1 sometimes	2 often
t001	I wear an apron when preparing meals	62%	25%	13%
t002	I change for different activities	12%	55%	33%
t003	Clothing is left for a couple of days and used again	44%	43%	13%
t004	I air clothing	20%	54%	26%
t005	if not enough I wash 40° and 60°C together in 40°C	52%	15%	33%
t006	clothing is turned inside out prior to washing	19%	34%	46%
t007	clothing with stains are worn another day	76%	19%	5%
t008	discarded clothing to family/friends/acquaintances	40%	35%	25%
t009	discarded clothing is given to charity	16%	33%	51%
t010	clothing is discarded in boxes of local government	45%	33%	22%
t011	clothing is discarded in the dustbin	63%	35%	3%
t012	underwear/household textiles as polishing rags	22%	36%	42%
		0 disagree		1 agree
t013	me and family members only wear new clothing	68%		32%
t014	I only buy clothing when I need to	45%		55%
t015	I enjoy shopping for clothing	39%		61%

What kind of washing machine do you have?

t016	... brand		
t017	top loader 13% front loader 77%	hot fill 0%	half automat 10%
t018	... kg capacity	t019	... where in the house
t020	... which floor in the house	t021	... age washing machine
t022	1 new 98% 2 second hand 2%	t023	... rpm spinning

Do you possess a separate spinner and how often do you use it?

t024	0 no 81%	1 yes 19%	t025	... times/week/month/year

		0 never	1 sometimes	2 often
t026	I do the laundry on one day in the week	75%	9%	16%
t027	I wash in the weekends	14%	37%	49%
t028	I wash regularly	6%	6%	88%
t029	I wash if the basket is full	5%	11%	84%
t030	I put the laundry in the machine and leave the house	18%	46%	36%
t031	I only wash when I am in the house	50%	31%	19%
t032	I wash at cheap/night rate	62%	19%	19%
t033	I combine 'doing the laundry' with household tasks	11%	25%	64%
t034	I try to wash everything in 1 day	76%	12%	12%
t035	I wash when family members need specific articles	57%	40%	3%

Do you wash cycles for others who do not live in the house?
t036 ... cycles/month/year

Table: What cycles do you normally wash per week and occasionally per year?
Name/Temperature/Programme/E-S-½ button/frequency per week-month-year/which articles/filling

t037	The white laundry is washed at ...°C			
t038	Have you washed this cycle at other temperatures in the past?			
0 no 36%	1 higher 36%	2 lower 21%	3 both 7%	
t039	... °C (if t038 = 1 or 3)		t039a	... °C (if t038 = 2 or 3)

Open question: why did you change to other temperatures?

In several countries laundry is washed at 25°C or even with cold water (10-15°C): for example, in Japan and Spain. What do you think about the idea to wash your coloured laundry at 25°C?

t040	0 no 54%	1 under conditions 25%	
	2 worth to try 17%	3 good idea 3%	No opinion 1%

Most washing machines are made for 4.5 to 5 kg of laundry. This means that the washing machine is completely filled with folded laundry and that after it is pressed down, nothing can be added. However, on average a Dutch household fills a washing machine with 3-3.5 kg of laundry. The following questions are about how you load your washing machine and why you do it that way.

How do you fill your washing machine, do you fold your laundry before putting it into the machine?

t041	1 loosely, not completely filled	32%
	2 loosely, completely filled	64%
	3 folded, not completely filled	3%
	4 folded and often completely full	1%

Open question: How do you see that the washing machine is full enough?

What are the reasons for not completely filling your machine?		0 no	1 yes	n.a
t042	laundry not clean enough	13%	85%	2%
t043	risk of damages to washing machines	63%	35%	2%
t044	laundry wears out more quickly	86%	12%	2%
t045	otherwise I have to wait too long	92%	6%	2%
t046	the laundry does not fit into the tumble dryer	91%	7%	2%
t047	I would have to fill up with extra laundry	88%	11%	2%
t048	loading would take too much time	84%	14%	2%
t049	other	75%	23%	2%

Would a smaller washing machine of 3.5 kg better suit your household and laundry practices?

t050	0 no 94%	1 maybe 2%	2 yes 3%	9 no opinion 1%

Open question to 050: why?

Would you load a smaller washing machine in the same way?

t051	0 exactly the same 75%	1 fuller 16%	2 no idea 9%

How many times do you wear or use the following articles?

t052	... blouses/men's shirts	t053	... T-shirts
t054	... jeans	t055	... sports clothing
t056	... bedding	t057	... towels (bathroom)
t058	... kitchen towels	t059	... woollen jumpers and cardigans
t060	... cotton jumpers		

What are you wearing today? t061a to t061r
What is your partner wearing today? t062a to t062r
What is your oldest child wearing today? t063a to t063r
(under-shirt/panties/half-slip/socks/stockings/tights/trousers/skirt/trouser-skirt/dress/T-shirt/blouse or men's shirt/cardigan/jumper/body warmer/vest/blazer-jacket/other)

What are the most important reasons for putting an article in the laundry basket?
1 very important 2 important 3 slightly important 4 unimportant

t065	after wearing/using it a fixed number of days	1 23%	2 23%	3 17%	4 35%
t066	if the article smells like body odour	1 74%	2 20%	3 4%	4 1%
t067	if the article smells like cigarette smoke or cooking	1 62%	2 32%	3 3%	4 3%
t068	if stains and spots are present	1 72%	2 24%	3 4%	4 -
t069	if the article no longer looks or feels neat enough	1 20%	2 30%	3 29%	4 21%
t070	if the article looks grubby	1 47%	2 36%	3 13%	4 4%

Do family members influence the textile maintenance process or your laundering practices?
t071 0 no 62% 1 yes 38%
Open question: How do family members influence laundering practices?

Where do you normally line dry your laundry and is this place heated?

t072	... place 1	t073	0 no 37%	1 yes, heated 49%	9 n.a 14%
t074	... place 2	t075	0 no 4%	1 yes, heated 7%	9 n.a. 89%

What types of detergents do you use?		no	yes
t080	total/heavy duty detergent	0 15%	1 85%
t081	colour detergent (traditional type, A)	0 59%	1 41%
t082	colour detergent (new type, B)	0 71%	1 29%
t083	speciality detergent (fine)	0 43%	1 57%
t084	wool/silk detergent	0 73%	1 27%
t085	bleach	0 96%	1 4%
t086	soak detergent	0 86%	1 14%
t087	softener	0 69%	1 31%
t088	stain detergent	0 67%	1 33%

t089	total number of types of detergents in use;				
if t082 =1: t090	Do you combine several colours in one load?				
	No 16%	Yes 12%	n.a. 72%		
t091	Do you consequently wash more articles in one load?				
	No 8%	Yes 4%	n.a. 88%		

What kind of materials are your sheets made of? 0 none 1 a few 2 most 7 don't know

t092	cotton	0 7%	1 8%	2 85%	-
t093	iron free cotton	0 58%	1 18%	2 17%	7%
t094	cotton/polyester	0 84%	1 8%	2 2%	6%
t095	other materials	0 90%	1 5%	2 2%	3%

How many articles do you use to make a bed?		0 no	1 yes
t096	mattress cover, flannel	0 12%	1 88%
t097	under-sheet, a small one	0 79%	1 21%
t098	1 sheet (under)	0 2%	1 98%
t099	2 sheets (under)	0 98%	1 2%
t100	duvet covers	0 8%	1 92%
t101	1 sheet (upper)	0 89%	1 11%
t101a	total number of articles	...	

Synthetic material or blends of a synthetic with cotton dry more quickly and are easier to iron. Gentleman shirts are mostly made of blends of polyester/cotton. Have you ever thought of buying sheets, duvet covers, and other bedding with not only cotton but also polyester in it: for example, a blend of 50/50? Why or why not?

t102	0	no, not acceptable either	77%
	1	yes, but they are not acceptable	11%
	2	yes, I already use those materials and they are not acceptable	8%
	3	yes, I already use those materials and they are acceptable	4%

Open question to t102: Why?

Woollen articles need to be cleaned less often than other materials, such as cotton. Would more woollen clothing or blends with wool be acceptable?

t103	0	no	43%
	1	yes, but I will not do it	22%
	2	yes, I already have a lot of wool	30%
	no opinion		5%

Open question to t103: Why?

Do you wash faded clothing more often to highlight the colours or to give it a fresh appearance again?

t104	0	no	72%
	1	yes	25%
	no idea		3%

Open question if t104=1: Can you tell more about this?

For how many years do you use woollen jumpers and cotton trousers or jeans before discarding them?
t105 ... years woollen jumpers t106 ... years cotton trousers/jeans

Do you own a tumble dryer?
t107 0 no 40% 1 yes 60%

Are you considering buying tumble dryer in the future?

t108	0	no	32%
	1	I have not thought about it	2%
	2	sometimes I think about it	4%
	3	yes, I will buy a tumble dryer in the future	2%
	n.a.	already has a dryer	60%

Open question: Why?

How many rooms and storeys do you use for textile maintenance?
t109 ... rooms t110 ... storeys

Has the fact that you have or had to carry your laundry from room to room influenced the wish for a tumble dryer?
t111 0 no 56% 1 yes, but unconsciously 3% 2 yes 10% n.a. 31%
Would you like to have a special room for textile maintenance?
t112 0 no 19% 1 already have one 30% 2 yes 51%
What would this special room look like?

t113	with a tumble dryer	0 no 28%	1 yes 54%	n.a. 18%
t114	with lines	0 no 10%	1 yes 73%	n.a. 18%
t115	adjacent to	n.a. 20%		

bathroom 22% bedroom 14% balcony 5% garden 12% kitchen 19% attic 7% cellar 1%
t116 ... m²
t117 on which floor? n.a. 18%
ground f. 36% 1st floor 14% attic 17% no preference 15%
t117a other wishes ... *(open question)*

Are you familiar with gas-fired dryers?
t118 0 no 80% 1 yes 20% 2 yes, I have one 0%

A gas-fired dryer is more expensive than an electric dryer but uses half the energy and finishes a cycle more quickly. However, the gas supply may need to be extended. The pay-back period is somewhere between 3 to 6 years, after which the gas-fired dryer is cheaper to use than an electric one. Would you be interested in a gas-fired dryer?
t119 0 no 53% 1 under conditions 35% 2 yes 0% no idea 12%
Open question: Why?

What kind of tumble dryer do you possess?

t120	... brand			
t121	1 condense dryer 31%	2 air-vented dryer 69%	3 gas-fired dryer 0%	
t122	1 timer 50%	2 dry programme 32%	3 both 18%	
t123	... where in the house			
t124	is this space heated?	0 no 45%	1 yes 55%	
t125	... age of the dryer	t126	1 new 89%	2 second-hand 11%
t127	1 A 2 B 3 C 4 D 5 E 6 F 7 G 8 do not know the energy class			

Open question: what were the reasons for purchasing a tumble dryer?

How do you normally fill your tumble dryer?
1 one load in two cycles 2 one load in one cycle 3 line dry some articles
4 ½ or ¼ in the dryer 5 some articles in dryer 6 everything is line dried 9 n.a.

t128	with white laundry	1 52%	2 7%	3 15%	4 14%	5 6%	6 6%	9 40%
t129	with light or coloured laundry	1 21%	2 7%	3 21%	4 26%	5 16%	6 9%	9 40%
t130	with synthetic or fine laundry	1 8%	2 2%	3 3%	4 13%	5 11%	6 63%	9 40%
t131	with hand washed articles	1 6%	2 -	3 -	4 2%	5 -	6 92%	9 40%

		disagree	agree	no idea	n.a.
t132	a cycle in the dryer costs less than 70 cents	37%	16%	47%	40%
t133	I dry everything cupboard dry	18%	80%	2%	41%
t134	also the pieces that need to be ironed cupboard dry	26%	69%	5%	40%
t135	tumble cycle costs 2 times or more energy than a wash cycle	11%	28%	61%	40%
t136	I use the dryer at the night rate	58%	36%	6%	40%
t137	I use the dryer in the summer as often as in the winter	71%	26%	3%	40%
t138	textiles suffer a lot from tumble drying	42%	50%	8%	40%

t140 Would you be prepared to wash differently?
0 no 49% 1 yes 51% Open question

t141 Would you be prepared to use the tumble dryer more selectively?
0 no 34% 1 yes 25% n.a. 41% Open question

t142 Would you be prepared to use other textile materials?
0 no 82% 1 yes 18% Open question

t143 Would you be prepared to use clothing and textile materials more days?
0 no 68% 1 yes 32% Open question

t144 Would you be prepared to make other changes in textile care?
0 no 83% 1 yes 17% Open question

Details of laundering

Use of programmes and special buttons

The use frequency of specific washing programmes and special buttons such as the energy saving button (E), and hand wash are described in more detail, as these variables directly influence the energy requirement for washing.

The distribution of the use of washing machine programmes is shown in Table 1, in the column '% of all cycles'. These cycles are the total number of cycles in the sample, washed by the 104 households in a period of a year. This is calculated from the data per household. The column '% of the cycles' shows that the four machine programmes (white, coloured, fine, and wool) and hand wash together amount to almost all the washes (97%)[35]. Note that these figures are based on estimates by households, which can be somewhat different from the reality.

Table 1 Use of washing machine programmes, load weight of machine washed cycles, and use of washing by hand

Machine programme	Of all cycles (%) n=39062	Used by households (%) n=104	Average load of all cycles (kg/cycle)
White/main	33	84	3.62
Coloured	39	70	3.41
Synthetics	.5	5	2.64
Fine	10	38	2.78
Wool	6	39	2.55
Short	.03	7	2.35
Other	2	2	3.25
Washing by hand	9	45	--

The column with '% of households' reflects the percentages of the 104 households that use such a programme. The column 'load' shows the average load weights of the cycles washed with the programmes. The calculation for the wash loads are based on the households that use the programmes. The cycles using the white programme have the highest wash load, followed by the 'colour' programmes. The wash load weights deviate from the advised loads. For white/main and coloured they are lower then the advised loads, for synthetics slightly higher than the advised load, and for fine and wool even higher by a factor of 2.5 or more. It is possible that households do not have the materials or do not wash the materials with the advised programmes. It might also be possible that households use, for instance, the term 'fine' for loads that are in fact synthetics loads; the high wash load for the fine programmes can be an indication for this.

The use of pre-wash and E-buttons (or E-programmes) is shown in Table 2.

[35] The results are to a large extent comparable with van Dijk and Siderius (1991), who found that the white programme is used for 30% of the cycles, coloured for 46%, fine/synthetics for 17%, wool and other programmes both for 3% - hand washing not included. As the authors do not differentiate between fine and synthetics, comparison of the use of synthetic programme is not possible.

Table 2 Use of pre-wash and E-buttons or programmes

Buttons or programme	Of all cycles (%)	Of all households (%)	Comparative data from literature* (% of households)	Present on washing machines (%)
Pre-wash	7.7	17	14	
E	13.1	26	20	57

* *Van Dijk and Siderius, 1991*

Roughly, the potential of households that could use E-buttons or programmes is a factor 2 higher. Compared with references in the literature, the percentages of households in the sample that pre-wash and use the E-button or programmes are a little higher.

Characteristics of the cycles washed with E-buttons or programmes are shown in Table 3. These characteristics are average temperature, average load, machine programmes with which the E-buttons are used, and how the cycles are labelled by the respondents.

Table 3 Characteristics of cycles washed using E-buttons or programmes: temperature, load, used machine programme, and label given by respondents

Average temperature (ºC)	Average load (kg/cycle)	Machine programme used			Labelled as		
		White (%)	Coloured (%)	Other (%)	White (%)	Coloured (%)	Other (%)
52	3.3	29	41	30	25	34	41

The load for the E-cycles is relatively high (3.3 kg). The E-cycle has a lower load weight compared with cycles washed with white programmes and possibly saves less than can be expected. E-buttons or programmes are mainly used for coloured programmes with ‘other loads’.

The use of E-buttons can lead to a reduction in energy use. Different types of E-buttons or programmes exist. Some buttons are intended to be used with cycles of 60ºC and higher. Instead of regulating washing at the selected temperatures, the E-button lowers the temperature by 10 to 20ºC; or a have a different heating pattern is used. Some E-programmes use less water. These programmes are intended for lightly soiled laundry. Most washing machine programmes will take longer to compensate for the lower temperatures. Another type of E-button simply prolongs the programme time and can be used with any temperature. The washing machine then comes with the advice to wash at lower temperatures and to use the E-button to compensate for the lower temperatures.

Households that use E-buttons or programmes have a higher average washing frequency, with 416 cycles per year instead of 375. Approximately one-quarter of the households (26) use E-buttons or programmes, washing 197 of their 416 cycles with it. In total, these households wash 13% of the total number of cycles washed by the total sample with an E-button or programme, or 5121 cycles. One-third of the households that use the E-button or programme use it for all their laundry. More than half of the cycles (53%) are washed at 40ºC or lower, and 95% at 60ºC or lower. The average temperature of cycles washed using an

E-button or programme is 52ºC. Cycles washed using an E-button or programme at 80ºC and higher are done by only four households, but these cycles take 24% of the cycles washed in that temperature class by all 104 households. In the data, no difference can be distinguished between the use of types of E-buttons or programmes. When the penetration rate of the type that simply prolongs the wash time is highest, most households use the E-button correctly.

Number and type of clothing articles that are used daily

To have an indication of how the number and type of articles that are worn daily influences the washing process, the respondent is asked what he/she, the partner, and the eldest child are wearing that day. The number of articles is, respectively, 4.2, 4.6 and 4.2 on average, with a standard deviation of 0.8. The difference in the number of articles worn has mainly to do with whether an undershirt is being worn (45% of the eldest children wear an undershirt), and whether the partner is wearing a blazer (28% of the partners wear one) in combination with a blouse or wearing just a blouse (in total 69% of the partners wear a blouse). As an indication, the variables ‘eldest child wears an undershirt’ and ‘partner wears a blazer’ are taken to show the correlations with other variables.

Table 4 Highest correlations between two distinguishing and other variables of wearing characteristics

‘Eldest child wearing an undershirt’	τ_c	‘Partner wearing a blazer’	τ_c
Age of eldest child	-.44	Professional status of partner**	-.39
No. wearing days of jeans	.39	Social economic class of partner	-.39
Washing frequency	-.34	Education of partner	.35
Kg of laundry per household	-.34	No. hours extra besides work hours	.30

*** Coded negatively*

The variable ‘eldest child wears an undershirt’ is clearly related to laundering variables, whereas ‘partner wears a blazer’ is related to social-economic, professional, and educational factors. In short, wearing more articles at the time is related to less laundry, to higher number of wearing days, to more sorting into laundry types (τ_c =.14), and to not having a dryer (τ_c =-.28).

Use of bedding

For most households, cotton is the predominant material for sheets (n=87). Iron-free cotton as the predominant material is used by 15 households and 2 have mainly cotton/polyester sheets.
Of the 93 households that answered the question:

- Most households use a large, thick mattress cover and one sheet to lie on (n=68). Thirteen households add a smaller mat to this combination. Six households use a single sheet and a smaller mat. Four households just use one sheet to lie on. Two households use double sheets to lie on, one with a mattress cover and one with a mat. The use of mats is related to shorter use of blouses and shirts (τ_c -.28, p.004), lower wash temperatures (τ_c -.24, p.011) and to less use of fund raising and collecting discarded clothing (τ_c -.16, p.039);
- Most households use duvet covers (n=86) and seven use top sheets. Three households use both duvet covers and top sheets. It is not asked whether these are used on one bed or on different beds.

The use of top sheets is related to the use of aprons (τ_c .21, p.010), a higher frequency of hand wash (τ_c .28, p.005), and a higher wash temperature (τ_c .19, p.018). The use of duvet covers is also related to lower wash temperatures (τ_c -.20, p.006) and to a lower frequency of hand washing (τ_c -.23, p.004). Both duvet covers and top sheets are related to the use of discarded articles as rags (resp. τ_c -.17, p.004; τ_c .18, p.006);

- The total number of articles on beds is 3.14 (s.d. 0.48) with a minimum of two and a maximum of five. It is significantly related to the use of mats (τ_c .47, p.000) and mattress covers (τ_c .16, p.040).

Non of the bedding variables are related to dryer ownership, dryer use, wearing days of six articles, wash frequency, total kg of laundry, load weights, folding laundry when loading the washing machine, items about shopping for clothes, environmental awareness, spinner possession, spinner use, or spin capacity. As described, some of the bedding variables are related to wash temperature, to items about textile discarding, and to frequency of hand washes.

Stock of clothing

It is established in the pre-survey that the stock of clothing can be best measured by the length of rods in clothing cupboards (see Appendix 4A), although establishing a measure for the stock of clothing is difficult. In the pre-survey, the lengths of rods in cupboards were 3.3 m per household and 1.6 m per person. It was established that this corresponds to an average of 28 kg of clothing per person: roughly 70 items in total.

In the case study, the length of rods varies from 60 cm to 8 metres, with one extreme of 15 metres. On average, households have 3.3 (s.d. 1.9 m) metres of rods and 0.8 m per person. In the pre-survey, single and couple households were also investigated, whereas the case study just focuses on family households. This might explain the lower length of rods per person in this survey.

The length of rods has an overrepresentation of 3 metres (n=18). A higher length of rods is significantly related to a higher age of the respondent and partner, a higher income, owning a house, more rooms, more often having a water-saving shower head, and to body odour being more important as an argument to launder, and a higher number of detergent types and laundry types are distinguished.

Lifetime, shopping, and discarding of clothes

The average lifetime of cotton trousers is 2.45 years (sd 1.5), with a minimum of 1 year and a maximum of 10 years. The average life time of woollen jumpers is much longer, 6.17 years (sd 4.6) with a minimum of 1 year and a maximum of 20 years. The seven highest significantly related variables with lifetime of cotton trousers are ‘education level of the partner/respondent’ (τ_c .38/.28, p.000), ‘socio-economic class of the partner/respondent’ (τ_c -.31/28, p.000), ‘rented or owned house’ (τ_c .308, p.003), ‘ARGWAS’ (τ_c .29, p.000), ‘wearing days of 6 articles (τ_c .26, p.001). For the lifetime of woollen jumpers these are again ‘education level of partner/respondent’ (τ_c .33/.33, p.000), ‘ARGWAS’ (τ_c .28, p.000) and ‘wearing days of six articles’ (τ_c .25, p.001). The use of a softener is negatively related (τ_c -.33, p.001).

Table 5 Manner of discarding articles in percentages of households (n=104)

Discarded articles go to…	Never	Sometimes	Often
Family, friends, etc.	40	35	25
Fund raising/door-to-door collection	16	33	51
Clothing depots (near supermarkets, etc.)	45	33	22
Dustbin	62	35	3
Used as rags	22	36	42

The way articles are discarded is not related significantly to the lifetime of these articles. Discarding methods are shown in Table 6.

Articles are used as rags more often in accordance with increasing age of the respondent (τ_c .25, p.005), the age of the eldest child (τ_c .216, p.006), and the age of the youngest child (τ_c .22, p.007). Articles are less often used as rags when a dryer is present (τ_c -.28, p.004) and when the respondent likes to shop for clothing (τ_c -.28, p.006).

Table 6 Shopping for clothes (% of households, n=104)

Shopping for clothes	Disagree	Agree
My family and I wear only newly bought clothes	68	32
I will only buy clothes when I need something	45	55
I like to shop for clothes	39	61

Neither the lifetime of articles nor the discarding methods are significantly related to one of these items about shopping for clothing. Wearing only newly bought clothes is related to a higher age of the eldest and the youngest child (τ_c .26, p.008; τ_c .43, p.000), to higher net income (τ_c .25, p.013), to laundering when family members need specific items (τ_c .23, p.012), and to more kg of laundry per person (τ_c .23, p.021).

Buying clothes only when needed is related to turning clothes inside out before washing, less use of detergents for wool and silk, higher white wash temperatures, washing when the basket is full, and if the partner wears undershirts. No demographic variables are related. It is worth noting that the importance of saving money and energy is part of the positive reaction to gas-fired dryers.

Respondents that like to shop for clothes are younger (τ_c:-.29, p.006), spend fewer hours extra apart from work hours outside the home (τ_c:-.31, p.002), less often use discarded articles as rags (τ_c -.28, p.006), use a softener more often (τ_c:.20, p.012), have fewer synthetic sheets (τ_c -.31, p.004), and like cotton better than wool (τ_c ..13, p.011).

Washing of faded colours

Faded colours are washed more often by 25% of the households. This is related to a higher age of the youngest child, to a water-saving showerhead being present more often, and to the partner wearing fewer T shirts and more blouses. No demographic, laundering, or other textile use variables are related.

Combining of household tasks

Approximately 11% of the households do not combine laundering with other household tasks, while 25% sometimes do. About 64% do this often or always. It is not asked which household tasks are combined with laundering.

Appendix 4C Variables in set 1, 2 and 3

The relation of the reduction options with other variables is assessed with correlation analyses using Kendal's tau c.

Table 1 Variables that are related more than once to the energy indicators (set 1)*

Social economic status of respondent	Wash at weekends
Social economic status of partner	Wash when basket is full
Household size	Use night rate
Arguments to launder	Dryer possession
No. of days woollen jumpers	Run lines led to wish dryer?
No. of days towels	Dryer in future?
No. of average number of wearing days	G: selective dryer use
Perceived influence of family members	Selective by? (alternative mentioned)
Total kg laundry/wash frequency	Wish for extra space/with dryer
Wash temperature in the past	Interest in gas-fired dryer
No change in wash temperatures in the past	Softener
Use duvet covers	Only newly bought clothes

**1. wash frequency, 2. weight of the load, 3. average wash temperature (in particular of coloured laundry) 4. number of laundry types, 5. dryer possession, 6. loading and use of the dryer, 7. textile use (average number of use days of six textile articles)*

Table 2 Variables that are related more than once with the answers to the 11 reduction options (set 2)*

Social economic status and education of respondent	G: wash differently?*
Social economic status of partner	G: longer textile use?*
Religion	Gas-fired dryer?*
Households size	Dryer possession
No. days woollen jumpers	Run lines led to wish dryer?
No. days towels	Dryer in future?
No. days cotton jumpers	Dry space heated
Total kg laundry and wash frequency	G: selective dryer use?*
Combine household tasks	Selective by? (alternative mentioned)
Use of energy-saving light bulbs	Wish for extra space?*/ with dryer/size/floor
Wash temperatures in the past	Will dry without a dryer

** Five reduction options are related more than once to other reduction options and are therefore mentioned in this Table; four reduction options are not related more than once and are left out in this Table and in Figure 4.9 (more wool; coloured laundry cold; CO/PE bedding; G: other solutions); but are included in the factor analysis.*

The following comments on these results can be made:

- Some determinants of acceptance are part of the laundering process itself, such as amount of laundry, wash frequency, and dryer possession;

- Of the laundering determinants, 'Religion' is only important for temperature choice. For acceptance it is more relevant;
- Important for both acceptance and laundering are the use time of textiles in days and whether run lines played a role in buying a dryer;
- More important for the acceptance of reduction options than for the laundering process are 'combining household tasks' and 'use of energy-saving light bulbs', unless the latter can be compared with the more general variable environmental awareness, which is of little importance in the laundering process.
- The relative importance of dryer and dryer reduction option related variables is remarkable.

It can be concluded that the response to the reduction options has demographic determinants but also ones that determine the laundering process; response to the reduction options is also related to other acceptance variables, in which dryer-related variables are relatively important.

Table 3 Variables that are related more than once to behaviour and intention variables (set 3)

Age of respondent	Dryer possession
Education of respondent and of partner	Dryer and dry space heated
Socio-economic status of respondent and partner	Run lines led to wish dryer?
Respondent has a paid job	Dryer in future?
Religion	Wish for extra space/with dryer/which floor
Household size	Interest in gas-fired dryer
Number of rooms/space per person	G: selective dryer use
Influence family members on laundering	Selective by? (alternative mentioned)
Arguments to wash	Use of top sheets
Average number of wearing days	Use of synthetic sheets
Wearing days woollen jumpers	Wash at the weekend
Leave clothes and wear again	Use of softener
Total kg laundry/wash frequency	
Wash temperature in the past	
No changes in temperature in the past	

Appendix 4D Results of factor analysis of 'Acceptance'

Rotated Component Matrix; Results of the factor analysis of the most often appearing variables

	Component							
	1	2	3	4	5	6	7	8
Dryer possession	.929							
Dryer in the future?	.936							
Run lines led to wish dryer?	-.784							
Space with dryer?	.741							
G: more selective dryer use?	-.905							
Will dry without dryer	-.709							
Dryer selective by (alternative)?	.748							
Education respondent		.726						
No. of days towels		.706						
No. of days woolen jumpers		.639						
No. of days cotton jumpers		.602						
SES (coded negatively)		-.701						
Wish special space laundry?			.849					
Space size?			.658					
Space which floor?			-.865					
Other temperatures past?				-.811				
More wool acceptable?				-.324				
Combine household tasks					-.551			
Coloured laundry cold?					.625			
Interest gas-fired dryer?					.402			
G: wash differently?					.676			
G: longer use of textiles?					.635			
Household size						.706		
Religion						.671		
Total kg laundry						.444		
Dry place heated?							.832	
Energy-saving light bulbs								.609
G: Other solutions?								.700
Thought of blends?								.514

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation.

a Rotation converged in 13 iterations, missings replaced with means, KMO .703; Bartlett's test of sphericity 980.096, p:.000; R^2:65%

Appendix 4E Relations of energy indicators and reduction options

Table 1 Relations of the energy indicators to other variables
(Kendal's tau c; $\tau_c \geq .13$; $p \leq .05$; laundering variables not included)

Laundering indicator	τ_c	Laundering indicator	τ_c
Washing frequency		Dryer possession	
No. of children and household size	.325	Type of house	-.276
Age of eldest child	.204	Household size	.228
Education/SES respondent/partner	-.312	Run lines lead to whish dryer?	-.734
Religion	.255	No change in wash temperatures	-.282
Leave clothes, wear again	-.366	Wash in the weekends	.232
No. of use days articles	-.443	Leave clothes, wear again/airing	-.259
Importance of arguments to launder	.257	Dryer in future	.963
Wearing of undershirts	-.332	Wool comfortable	-.233
Wool laborious	.284	Wash temperature past	.231
Amount of laundry			
Combine laundering- household tasks	.166		
Wash temperature past	.197	Use of heavy duty detergents	
Number of days that articles are used		Use of night rate	.175
Education/SES respondent/partner	.302	Household size	+.
Respondent paid job/extra hours away	.175	Use of colour detergents	
Leave clothes, wear again	.421	Net income	-.
Airing/spots another day	.242	Launder only when at home	.179
Importance of arguments to launder	-.315	Use of wool/silk detergents	
Life wool jumpers/cotton trousers	.251	Age respondent	.274
Environmental awareness	.134	Education partner/SES	.304
Eco-labeled products	.240	Nett income	.268
Load weight		Cotton/polyester sheets	-.166
Way of loading the washing machine	.290	Wear apron	.221
Life cotton trousers	.208	Dryer filling hand wash laundry	.291
Wash faded colours more often	-.226	Use of specialty/fine detergents	
Education respondent (partner)	.198	Water-saving shower heads	.204
Environmental awareness	.141	Life cotton trousers	.202
Average wash temperature		Use of softeners	
Use of night rate	-.171	Education respondent/partner	-.393
Religion	.170	No. days trousers/towels	-.268
Use of duvet covers	-.203	Importance of arguments to launder	.278
Use of under sheets	-.237	Use of synthetic sheets	-.327
Use of top sheets	.190	Wool wears comfortable	-.144
No. of days bedding	-.144		
Experienced influence family members	-.245	Use of stain-pretreaters	

Wash temperature coloured laundry	
No change in wash temperatures	.301
Wash in the weekends	-.215
Wash when basket is full	-.211
Only newly bought clothing	.216
Age washing machine	-.135
Wash temperature past	-.247
Wash temperature white laundry	
Experienced influence of family members	-.230
Importance of spots/stains to launder	.171
No. of laundry types (general)	
Age partner (respondent, eldest child)	.180
Length of rods	.208
Partner (respondent) wears undershirt	.382
Use of molton cotton (no. of bedding articles)	.195
Energy-saving light bulbs	.217
Age eldest	.239
Wear articles with spots another day	-.176
Importance of spots/stains to launder	.206
No. of days T shirts	-.237
Combine laundering-household tasks	.169
No. of Detergents	
Importance of spots/stains to launder	.177
Age respondent	.159
No. of rooms used for laundering	
Number of floors	.461
Dryer new/2^{nd} hand	.283
Respondent paid job	.206

**Laundering indicators that are not significantly related to other variables are: Frequency of dryer use; Average dryer load weigh; Use of soak detergents; Dry space heated.*

Table 2 Relations between acceptance of 5 general and 6 single options, and household characteristics Significance at α=.05 (τ_c = > ±.13)

Variable	Description	τ	Variable	Description	τ
T104	G: Wash differently? n=104		T103	More wool n=99	
A002	Type of house	0.15	A008	Age respondent	0.20
A007	Total number of inhabitants	-0.14	A017	Education respondent	0.20
A010	Age eldest child	-0.25	A018	Education partner	0.16
A017	Education of respondent	0.18	A025	Professional status partner	-0.22
A018	Education of partner	0.19	A026	Resp no. of extra hours	0.15
A020	Respondent has paid job	0.15	A031	No. of rooms	0.19
A022	Professional status of resp.	-0.19	A038	Partner cooks	0.15
A025	Professional status of partner	-0.16	A045	Use water-saving shower h.	0.14
A027	Partner no. of extra hours	0.23	A046	Use energy-saving light b.	0.16
A029	Religion	-0.16	ruimtep	Relative space per person	0.15
A034	Partner does laundry	0.15	SES	Social economic class man	-0.21
A038	Partner cooks	0.17	SESV	SES woman	-0.13
A043	Buy eco-labelled products	0.19	aa002	Type of town	0.156
A045	Water saving shower head	-0.25			
SES	Social economic class man	-0.245	T119	Gas-fired dryer n=104	
T033	Combine household tasks	-0.281	A002	Type of house	-0.17
			A003	No. of children in house	0.16
T141	G: More selective dryer use n=62		A007	Total no. of inhabitants	0.246
aa002	Size of town	0.19	A024	Partner work no. of hours	0.16
A010	Age of the eldest child	-0.21	A029	Religion	0.178
A027	Partner extra hours	0.25	A025	Professional status partner	-0.17
A002	Type of house	0.217	A046	Use of energy-saving light bulbs	0.19
			milieu	Scale for environmental awareness	0.17
T142	G: Other textile materials n=104				
A020	Respondent has paid job	0.14	T040	Washing at 25°C n=103	
A021	Respondent no. of hours work	0.13	A017	Education respondent	0.17
A022	Professional status respondent	-0.16	A018	Education partner	0.13
A046	Use of energy-saving light bulbs	0.15	A020	Respondent has paid job	0.23
			A021	Respondent no. work hours	0.26
T143	G: Longer use of textiles n=104		A022	Professional status respondent	-0.26
A008	Age of respondent	0.14	A043	Buy eco-labelled products	0.24
A026	No. of extra hours respondent	0.17	SES	Socio-economic class man	-0.15

A031	No. of rooms in the house	0.20
A046	Use of energy-saving light bulbs	0.15
T033	Combine household tasks	-.206
T008	Old textiles for family etc.	0.234
T144	G: Other solutions? n=104	
A017	Education respondent	0.209
A027	Partner extra hours	0.152
A030	Rented/owned house	0.136
A046	Use of energy saving light bulbs	0.195
T102	Blends for bedding n=103	
A046	Use of energy-saving light bulbs	0.183
T012	Use old textiles as rags	0.158
SESV	Socio-economic class woman	-0.17
T033	Combine household tasks	-.221
T112	Extra space for laundering	n=102
A031	No. of rooms	-0.208
	Space pp	-0.203
T050	Smaller washing machine	
	No significant relations	

Appendix 5A Regression and Anova analyses of Willingness and Use

Results of the original solutions of the regression analyses of Willingness and Use, and the Anova analyses of differences in Willingness and Use between the top and mainstream group

Table 1 Results for the regression analysis of Willingness to Change (31 options)

Included variables	Unstandardised Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.268	3.368		.970	.333
Hours from home per week (P + R)	.004	.009	.037	.457	.648
Commodity use	.356	.241	.097	1.477	.141
Home production	.384	.252	.087	1.525	.129
Use of options 0-28 (USE scale)	.113	.069	.115	1.648	.100
Application scale	.074	.026	.182	2.844	.005
Knowledge 32 options	-.020	.021	-.058	-.924	.356
Time	.054	.031	.115	1.745	.082
Importance scale	.054	.053	.064	1.017	.310
Pleasure scale	-.028	.052	-.034	-.534	.594
Task division	.031	.019	.104	1.592	.113
Frequency of confer	-.014	.022	-.048	-.640	.523
Combining scale	.000	.000	.136	2.327	.021
Env. Awareness scale	.056	.048	.073	1.161	.247
No. of children at home	-.749	.220	-.192	-3.409	.001
Age of respondent	-.022	.026	-.049	-.836	.404
Education respondent	.267	.135	.133	1.982	.049
Paid job respondent	-.134	.421	-.021	-.318	.750
Net income/month	-.139	.215	-.051	-.644	.520
Household help	-.395	.611	-.039	-.645	.519

Dependent Variable: Willingness of 31 options; Original model with 19 variables; Enter method, missings pair-wise deleted. Adjusted R^2: 11%; 100% of the sample

Table 2 Results for the regression analysis of the Use scale (28 behaviours)

Included variables	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	13.909	2.846		4.887	.000
Hours from home per week (P+R)	-.006	.008	-.048	-.686	.493
Commodity use	-1.245	.199	-.332	-6.261	.000
Home production	.028	.222	.006	.127	.899
Application scale	.038	.023	.091	1.654	.099
Knowledge 32 options	.057	.018	.167	3.118	.002
Time	-.028	.027	-.058	-1.026	.306
Importance	-.053	.047	-.062	-1.129	.260
Pleasure	.010	.045	.012	.211	.833
Task division	.004	.017	.012	.216	.829
Frequency of confer	-.029	.019	-.096	-1.471	.142
Combining	.000	.000	-.054	-1.068	.287
Env. Awareness scale	.026	.042	.033	.613	.540
No. of kids at home	-.179	.193	-.045	-.923	.357
Age respondent	-.007	.023	-.016	-.319	.750
Education respondent	.517	.114	.254	4.522	.000
Paid job respondent	-.453	.370	-.069	-1.226	.221
Net income/month	-.127	.189	-.046	-.670	.503
Household help	-.872	.536	-.085	-1.627	.105

Dependent Variable: Use of options 0-28; Original model with 19 variables; Enter method, missings pair-wise deleted. Adjusted R^2: 34%; 100% of the sample

Table 3 Differences in Willingness and Use between the top and mainstream group (Anova, mean, p<.05, n=376) in average scores

Willingness	Mean values			Use	Mean values		
	Top (n=55)	Mainstream (n=316)	F		Top (n=57)	Mainstream (n=287)	F
Application	17.5	14.9	4.9*	Application	19.5	14.7	16.9***
Knowledge e.s. white good	1.55	1.74	5.5*	Knowledge	54.3	48.2	18.9***
Freq. of confer care and guidance	2.25	2.66	4.1*	Freq. of Confer	17.7	22.0	7.5**
Solar boiler possession	.82	.41	26.7***	Partner living in	.68	.84	8.2**
Freeze one pot meals	.52	.37	4.6*	Education R.	5.0	4.2	11.7***
Combining	2025	1565	6.2*	Net income	2.5	2.9	4.3*
				Ownership house	.54	.71	5.9*
				Hours from home R. + P.	49.3	58.5	5.5*
				Willingness	11.4	10.0	7.9**

**: p<.05; **: p<.01; ***: p<.001*

For Willingness, the top group scores higher on Application, solar boiler possession, freezing one- pot meals, and Combining. Their familiarity with energy-saving white goods is lower and they confer less with their partner about the care and guidance of children. The findings confirm the notion that when the partners have a separate routine there is space for unusual change.

For Use, the top group scores higher on Application, Knowledge, Education of respondent, and Willingness, and lower on partner living in the house, Frequency of Confer, net income, owned house, and hours away from home by both the respondent and the partner. Apparently the situation leads to more energy-friendly household behaviour and at the same time to more knowledge about it and willingness to behave accordingly.

The significant differences in use and willingness items on a disaggregated level are not mentioned in the table, as these are present in the concepts Use and Willingness.

Table 4 Correlation analyses for number of children in the mainstream group (for Willingness, n=318; p<.01, Willingness variables excluded)

Variable	τ_c	Variable	τ_c
Total inhabitants	.66	Wearing days jeans	-.09
Combine cleaning & laundering	.14	Dryer ownership	.23
Combine purchases & transport kids	.16	Dryer frequency	.16
Gas use (m^3)	.16	Wash frequency	.25
Electricity use (m^3)	.18	Fill rate dryer	.14
Environment role using dryer?	-.15	Combining	.11
Meat replacements cost money	.17	Gas use per person	-.19
Freq. pre-frozen meat replacements	-.09	Electricity use per person	-.16
Freeze leftovers	-.18	Willingness	-.13
Freeze capacity	.09	Commodity use	.13
Freq. fresh vegetables in winter	-.09		

Table 5 Correlation analyses for Combining in the mainstream group (for Willingness, n=318; p<.01, Willingess variables excluded)

Variable	τ_c	Variable	τ_c
Number of children	.11	Wearing days jeans	-.11
Age respondent	-.17	Wearing days bathroom towels	-.14
Age partner	-.16	Dryer frequency	.12
Age youngest child	-.13	Wash frequency	.14
Education respondent	-.17	For env. dryer use more selectively	.14
Importance result house	.12	Part laundry not in dryer	.10
Importance result purchases	.14	Knowledge sharing cars	-.20
Need info e.s.light bulbs	.11	Knowledge seasonal vegetables	-.13
Freq. poultry	.12	Importance of result of tasks	.11
Freq. pre-frozen poultry	.22	Use of natural floor materials	-.13
Freq. pre-frozen meat snacks	.22	Use	-.15
Freq. pre-frozen potato products	.30	Considered (follow-up survey)	.16
Freq. pre-frozen vegetables	.14	Tried (follow-up survey)	.16
Freq. fresh vegetables in winter	-.14	Succeeded (follow-up survey)	.16

The two lists of correlations indicate the variety in household organization, mainly with regard to freezer use, use of fresh vegetables, importance of the results of tasks (for Combining), for wearing days (jeans), dryer ownership and dryer and wash frequency. The correlations also denote the variety in energy requirements in absolute and relative (for number of children) or indirect terms (for Combining).

Appendix 5B Factor analyses of household organisation aspects

Table 1 Factor analysis for Combining

'Combining'	Component	
R^2 46%	1	2
Cooking and household jobs/cleaning	.603	.241
Hot meal and friends	.138	.484
Cooking and Care children	.453	.281
Cooking and news paper/TV/music	.613	.107
Cleaning and doing the laundry	.770	.142
Doing laundry and reading newspaper/TV/music	.787	-.086
Shopping and services	.311	.430
Travel for work and shopping	.037	.784
Travel for work and transport children	-.035	.749
Shopping and transport children	.318	.645

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. Rotation converged in 3 iterations; missings replaced by means

Table 2 Factor analysis for Task division

'Task division'	Component	
R^2 62%	1	2
Food	.190	.805
House	.116	.715
Clothing/Shoes	.167	.723
Shopping	.251	.743
Care and guidance	.490	.644
Work/study	.750	-.102
Other activities and help	.736	.255
Leisure time	.746	.330
Social contacts	.724	.277
Organising planning	.698	.341
Large purchases	.773	.320

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. Rotation converged in 3 iterations; missings replaced by means

Table 3 Factor analysis for Frequency of Confer

'Frequency of confer' (with 3 forced factors)	Component		
R^2 88%	1	2	3
Food	.493	.790	.125
House	.506	.779	.191
Clothing/Shoes	.274	.789	.398
Shopping	.476	.745	.246
Care and guidance	.737	.531	.177
Work/study	.745	.441	.240
Other activities and help	.793	.353	.365
Leisure time	.776	.420	.327
Social contacts	.761	.431	.335
Large purchases	.346	.249	.886

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. Rotation converged in 7 iterations; missings replaced by means

Table 4 Factor analysis for Pleasure

'Pleasure'	Component		
R^2 51%	1	2	3
Food	.073	.654	.109
House	.004	.794	.139
Clothing/Shoes	.047	.679	.187
Shopping	.045	.282	.501
Care and guidance	.469	.301	.178
Work/study	.494	.215	-.040
Other activities and help	.694	.141	.040
Leisure time	.801	-.153	.056
Social contacts	.715	-.176	.165
Organising planning	.056	.111	.766
Large purchases	.130	.096	.807

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. Rotation converged in 5 iterations; missings replaced by means

Table 5 Factor analysis for Importance of Tasks

'Importance of tasks'	Component		
R^2 55%	1	2	3
Food	.664	.193	.027
House	.836	.019	.083
Clothing/Shoes	.776	.072	.086
Shopping	.621	.067	.289
Care and guidance	.344	.354	.255
Work/study	.138	.226	.534
Other activities and help	.081	.682	.099
Leisure time	.108	.826	.009
Social contacts	.073	.803	.082
Organising planning	.060	.117	.787
Large purchases	.146	-.093	.767

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. Rotation converged in 4 iterations; missings replaced by means

Table 6 Factor analysis for Perceived Time

'Perceived Time'	Component	
R^2 60%	1	2
Food	.810	.125
House	.834	.267
Clothing/Shoes	.808	.255
Shopping	.759	.243
Care and guidance	.490	.401
Work/study	.006	.597
Other activities and help	.284	.755
Leisure time	.308	.776
Social contacts	.280	.751
Organising planning	.295	.722
Large purchases	.398	.532

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. Rotation converged in 3 iterations; missings replaced by means

Appendix 5C Knowledge of the 31 reduction options (%, n=376)

Table 1 Knowledge of the 31 reduction options

Familiar with:	Missing	No	Vaguely	Yes
Solar boiler?	4	8.9	26.6	64.5
Water-saving shower head?	4	0.9	5.6	93.5
Natural materials for floor covering?	5	6.5	15.6	77.9
Energy-saving light bulbs?	5	-	3.0	97.0
Sharing car through a company?	7	32.2	33.9	33.9
Sharing a car with another household?	6	24.6	29.2	46.2
Lighter weight car?	6	7.3	18.4	74.3
Driving less?	4	1.1	1.3	97.6
Most energy efficient appliances?	6	6.5	15.7	77.8
Not replacing the dryer?	14	11.6	9.7	78.7
Not replacing the freezer?	10	12.6	13.1	74.3
Smaller refrigerator?	7	11.9	14.4	73.7
Smaller freezer?	10	11.5	14.2	74.3
Heat one degree lower?	4	1.1	3.5	95.4
Green electricity?	7	29.5	22.0	48.5
Pre-rinse the dishes cold?	7	14.9	21.7	63.4
Replace cut flowers with plants?	6	37.8	24.9	37.3
Replace cut flowers with ecologically grown flowers?	6	48.6	24.6	26.8
Replace cut flowers with other gifts?	5	29.9	19.2	50.9
Change to more public transport?	7	4.6	5.7	89.7
Change to more bicycle riding?	4	0.3	2.4	97.3
Abandoning the car?	7	4.0	3.0	93.0
Replace fresh vegetables in the winter with conserved vegetables?	6	32.7	34.1	33.2
Replace frozen vegetables with conserved vegetables?	5	38.8	30.2	31.0
Only eat vegetables in season?	5	9.1	14.6	76.3
Replace meat?	8	21.2	24.7	54.1
Holiday closer to home?	6	9.5	13.5	77.0
Holiday fewer and further and longer?	6	25.4	24.9	49.7
Tent instead of an apartment?	8	23.4	17.1	59.5
Use the dryer selectively?	15	5.3	5.3	89.4
Wash at lower temperatures?	5	2.4	5.7	91.9
Wear and use textiles longer before washing them?	8	6.8	9.5	83.7

Appendix 5D Factor analyses of five aggregated variables

Table 1 Factor analyses of reduction options with the 0/1 Willingness variables (1st set of variables)

Items/components	1	2	3	4	5	6	7	8	9	10	11	12
Solar boiler	.67											
Water-saving shower heads											.82	
Natural floor materials					-.63							
Energy-saving light bulbs								.81				
Car shared (company)			.45									
Car shared with households		.63										
More public transport	.71											
Lighter car							.79					
Drive less											.51	
Use of bicycles/mopeds									.73			
Abandon the car			.67									
Energy efficient appliances	.42											
Not replace the dryer		.59										
Not replace the freezer		.84										
Smaller refrigerator						.35						
Smaller freezer												.81
Heating less									.52			
Green electricity							.57					
Pre-rinse dishes cold								.44				
Plants instead of flowers										.82		
Gifts instead of flowers			.40									
Eco-flowers i.s.o. flowers							.39					
Conserved i.s.o. frozen veg.							.54					
Conserved i.s.o. fresh veg.			.43									
Meat replacements				.55								
More chicken						.61						
More fish						.84						
Holidays closer to home			.77									
Holidays longer/further/fewer			.58									
Tent i.s.o. apartment									.56			
Use the dryer selectively				.75								
Wash at lower temperatures				.77								
Use textiles longer					.78							

Principal Component Analysis, Varimax rotation, 28 iterations, missings replaced by means, KMO: .374, Bartlett's Test of Sphericity: p:.050, R^2: 70%

Table 2 Factor analyses of reduction options with the 0/1 Attractiveness variables (2nd set of variables)

Items/Components	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Solar boiler								-.38						
Water-saving shower head										-.32				
Natural floor materials										-.42				
Energy-saving light bulbs								.56						
Shared car (company)		.71												
Shared car (households)		.81												
More public transport												.78		
Lighter car														-.84
Drive less								.56						
More bicycles/mopeds					.46									
Abandon the car													.85	
Energy efficient appliance												.28		
Not replace the dryer												.55		
Not replace the freezer			.78											
Smaller refrigerator							.65							
Smaller freezer							.81							
Heating less				.65										
Green electricity						.42								
Pre-rinse dishes cold					-.72									
Plants instead of flowers									.47					
Gifts instead of flowers					-.38									
Eco-flowers i.s.o. flowers						.80								
Conserved i.s.o. frozen veg	.70													
Conserved i.s.o. fresh veg	.73													
Replace meat											-.25			
Holidays closer to home									.73					
H.longer/further/fewer			.77											
Tent i.s.o. apartment										.70				
Selective dryer use											.77			
Lower wash temperatures				.63										
Use textiles longer								.50						

Principal component analysis, varimax rotation, Kaiser normalisation, missings replaced by means; KMO: .518; Bartlett's Test of Sphericity: p:. 000; R^2: 59%; iterations: 31

Table 3 Factor Analysis: Rotated Component Matrix of 'Application'

R^2 48%	Component	
Environment plays a role in/with ...	1	2
Pre-rinsing dishes?	.232	.615
Heating the house?	.181	.749
Driving the car?	.104	.684
Going on holiday?	.539	.451
Buying of flowers?	.585	.266
Eating meat?	.759	.234
Consuming frozen vegetables?	.803	.113
Consuming fresh vegetables in the winter?	.716	.294
Using the dryer?	.355	.007
Choosing wash temperatures?	.068	.704
Wearing of clothing?	.281	.496

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation.

Rotation converged in 3 iterations, missings replaced by means

Table 4 Factor Analysis: Rotated Component Matrix of 'Knowing'

Items	Component									
	1	2	3	4	5	6	7	8	9	10
Solar boiler?							.638			
Water-saving shower head?										.403
Natural floor materials?								.407		
Energy-saving light bulbs?										.790
Sharing car through a company?						.856				
Sharing a car other household?						.789				
Lighter weight car?								.745		
Driving less?								.615		
Most energy efficient appliances?									.737	
Not replacing the dryer?		.835								
Not replacing the freezer?		.891								
Smaller refrigerator?		.866								
Smaller freezer?		.878								
Heat one degree lower?									.383	
Green electricity?							.824			
Pre-rinse the dishes cold?									.350	
Replace cut flowers with plants?	.745									
Replace flowers with eco-flowers?	.514									
Replace cut flowers with gifts?	.724									
Change to more public transport?					.769					
Change to more bicycle riding?					.701					
Abandoning the car?					.711					
Replace fresh vegetables?	.803									
Replace frozen vegetables?	.793									
Seasonal vegetables?	.460									
Replace meat?				.433						
Holiday closer to home?				.728						
Holiday fewer/further/longer?				.731						
Tent instead of an apartment?				.697						
Use the dryer selectively?			.712							
Wash at lower temperatures?			.758							
Wear/use textiles longer?			.724							

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. R^2: 65%, KMO: .596; Bartlett's Test of Sphericity: p:. 000; 11 iterations

Table 5 Factor Analysis: Rotated Component Matrix of 'Use of 28 behaviours'

Items	Component										
	1	2	3	4	5	6	7	8	9	10	11
Wash temperatures							-.40				
Wearing days			.689								
Solar boiler 0/1					.632						
Water-saving shower head 0/1									.378		
Natural floor materials 0/1							.733				
Energy-saving light bulbs 0/1									.629		
Car shared with other households								.697			
Weight car 0/1		.861									
Mileage 0/1		.497									
No car/shared car – car possession		.777									
Dryer possession 0/1	.919										
Freezer possession 0/1				.734							
Cool capacity 0/1				-.46							
Freeze capacity 0/1				.816							
Heating behaviour								.390			
Green electricity 0/1					.790						
Pre-rinse dishes cold 0/1											.846
Buying flowers for others 0/1								-.51			
Use of greenhouse vegetables										-.44	
Chicken consumption						.717					
Fish consumption						.779					
Use of meat replacements 0/1							.463				
Use of tent			.568								
Dryer use frequency 0/1	.793										
Dryer filling 0/1	.898										
Shared car through company 0/1									-.69		
Use of pre-frozen vegetables 0/1										.794	
Holiday frequency			-.46								

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation; 12 iterations, KMO: .596; Bartlett's Test of Sphericity: p:. 000; R^2: 61%

Appendix 5E Follow-up survey 2000

1. Questionnaire

During the past year, have you: thought about (no/yes); tried (no/yes) the following?
Did you succeed (no/yes)? Or was it:
1. not necessary to replace yet
2. cannot or do not want to change
3. already a practice in my household
4. not applicable

Solar boiler	Plants i.s.o. cut flowers
Water-saving shower heads	Eco-flowers i.s.o. cut flowers
Natural materials for floors	Presents i.s.o. cut flowers
Energy-saving light bulbs	km by public transport i.s.o. by car
Car sharing through a company	km by bike i.s.o. by car
Share car with another household	Discard the car
Lighter car	Conserved vegetables i.s.o. greenhouse
Drive the car less	Conserved vegetables i.s.o. frozen
Energy-efficient appliances	Just seasonal vegetables
Not replace the dryer	Meat replacements
Not replace the freezer	Holiday closer to home
Little fridge next time	Holiday fewer/longer/further
Little freezer next time	Tent i.s.o. an apartment
Heating 1˚C less	Use the dryer selectively
Green electricity	Wash at lower temperatures
Pre-rinse dishes cold	Use clothes and textiles longer

If you would like to write down your experiences with energy-saving measures, please use the following page.

2. Representativeness

Differences between households that returned or did not return the follow-up survey:

Demographic variables in non-response households:
- The partner has on average a higher education level (Anova, means, F: 4.7, p:.03)
- The number of hours for other obligations than work and commuting time is higher, both for the respondent (on average 5.1 vs. 3.7 hours/week, Anova, means, F: 4.6, p:.03) and the partner (on average 4.5 vs. 2.8 hours/week, Anova, means, F: 4.8, p:.03).

Motivational variables, the non-response households:
- Intend to move more often within 3 years (Anova, means, F: 6.2, p:.01)
- Less liked to fill in the questionnaire (Anova, means, F: 21.3, p:.00).

Organisational aspects, in the non-response households:

- Households tasks are relatively more often done by the men ('Task division': 33.4 vs. 30.8, Anova, means, F: 5.5, p: .02).

Functional level; in the non-response households:
- The number of energy-saving light bulbs is lower (2.8 vs. 3.7, Anova, means; F:4.9, p:.03);
- The cool capacity is higher (223 litre vs. 202 litre, Anova, means; F:4.3, p:.04) and they more often have a cupboard model refrigerator (no 0/yes 1) (.27 vs. .15, Anova, means; F:9.1 p:.003);
- The wash temperature coloured laundry is higher (42°C vs. 40°C, Anova, means; F:4.0, p:.045) compared with households that returned the follow-up survey.

Responses to some of the single reduction options differ as well, but in general the scores on Willingness or Use do not differ.

Appendix 5F Overview of seasonal vegetables

	Spring	Summer	Autumn	Winter
Green beans		*		
Carrots	*	*	*	Stored
Spinach	*			
(Red) cabbage		*	*	Stored
Beetroot		*		Stored
Peas	*	*		
Other legumes	*	*		
Kale			*	*

Recepten waaier, Alternatieve Consumenten Bond

Summary Energy and Households

Introduction

Anthropogenic greenhouse gas emissions substantially worsen the greenhouse effect. This effect is a natural process whereby gasses in the atmosphere absorb infrared radiation. Increased concentrations of greenhouse gasses cause the atmosphere to retain more warmth than usual. A major source of greenhouse gas emissions is the combustion of fossil fuels, used for the generation of electricity and for transport and production processes. Energy requirement can be distinguished in direct energy consumption through energy carriers, such as electricity and gas, and in indirect energy consumption that is used for production, distribution, and the trade of goods and services. Due to their direct and indirect energy consumption, households in the Netherlands use 40-60 percent of the total national energy requirement, and even up to 70 percent when social services like health care are included. The household can be seen as the smallest metaphor for the consumption and production society of the Netherlands BV (Nonhebel, 2000). Individual consumers, organised into households, largely determine what kind, how much, and in what way goods and services are produced. To save energy, transitions are needed on this micro level, which in turn affect the macro level. Changes in demand-side consumption structures are expected to be supportive in achieving long-term national energy reduction targets.

Public concern about the energy crisis and eventually other social-psychological factors of energy conservation behaviour has been under investigation since the oil crises in the early 1970s. Compared with individual behavioural change, the influence of the household situation, along with the performance and the organisation of functional activities, has been investigated less often. Research has indicated that although people are willing to save energy and to care for the environment, the actual changes in energy-consuming behaviour are limited. For this thesis, research has been done on the influence of household management on the willingness to accept energy reduction options. The common assumption that intention will lead to a change in behaviour was abandoned and instead the relation between intention and actual behaviour was examined. This included factors that determine actual behaviour as well as the willingness to change, such as the actual performance of household activities and aspects of their organisation.

By studying the activities of households, interaction between direct and indirect energy requirements can be examined in detail and burden shifting is avoided. In a study of behavioural changes within households, several aspects need to be taken into account: for instance, the conditions for acting, the composition of the household group, and how a level of well-being is achieved through household management. The acceptance of change and thus the energy reduction potential is affected if changes do not fit conditions, lead to an inefficient use of household resources, or endanger the level of living.

The environmental burden of households arises at a functional level, whereas implementing more than one reduction option was expected to require organisational skills. This made it relevant to investigate both the performance and the organisation of functional household activities. Therefore, the overall research question was:

> *What is the influence of household management aspects on the acceptance and energy-saving potential of greenhouse gas reduction options?*

The question was investigated by means of three surveys: a case study of Textile Care with 6 energy reduction options to do with laundering; a general survey that included a range of 31 different reduction options for direct and indirect energy; and a follow-up survey a year later, in which the actual change was investigated.

Energy-saving potential

Within the Lifestyle project (1990-1995) of the National Research Programme on Global Air Pollution and Climate Change I, the energy requirements of more than 350 household expenditure categories of products and services were calculated, using a hybrid method that combined process analysis and input-output analysis. Studies within the Lifestyle project focused on differentiating lifestyle patterns in consumption expenditures, and turned out to be fruitless. The variation within consumption categories was higher than for the total energy requirement, which nevertheless indicates differences in consumption patterns. Reduction options for indirect energy turned out to be fragmented and with small saving potentials. Therefore, direct energy reduction options are also included, in this thesis, because they:

- increase the possible savings impact, which decreases the relative effort to investigate reduction options compared with the theoretical saving potential;
- make comparisons with indirect energy reduction options possible;
- enable interaction between direct and indirect options to be investigated as well.

The categories of reduction options chosen are shown in Table A.

Selection criteria were that the reduction potential per option was at least 0.5 GigaJoule per household per year and the total set of options should be divided over practices as well as investment and purchases. Options also had to be readily available for households as well. The theoretical energy saving potential of the reduction options (products and activities) was estimated using different methods, with either national expenditure averages, national usage averages, or per application. The options were related to nearly 75 percent of the total household energy consumption (240 GJ/y), and the theoretical saving potential of these options—including interaction effects—was 26 percent. In practice, the domestic energy-saving potential will depend on the theoretical potential, the acceptance of the options by households, and the magnitude of change at the functional level.

Table A Categories of reduction options investigated

	Use/activities/practices	Investments/purchases
Direct energy requirement	Heating	Energy-saving light bulbs
	Car use	Solar boiler
	Wash temperature**	Green electricity
	Use of washing machine/dryer**	Water-saving shower heads
	Pre-rinsing dishes**	Alternatives for appliances**
Indirect energy requirements	Holidays	Floor covering
	Use of textiles**	Alternatives for flowers
	Textile materials*	Meat (substitution, vegetarian)**
		Vegetables**

** investigated in the case study only; ** investigated in the case study and the general survey*

Households and behavioural change

The willingness of households to accept reduction options was investigated from a functional household science perspective. This perspective focuses on the functional activities in the household system, which provide for the daily as well as the long-term well-being of household members. These activities consist of production, consumption, resource acquisition, maintenance, governance of processes, storage, discarding, decision making, and organisation, whereby immaterial and material resources and standards of living are applied by households. All of these depend upon the household situation as well as the influence of environments.

Respondents are not only representatives of the household and the performers of household activities but they are household managers and gatekeepers of changes as well, and individual determinants feature in these roles. Therefore, the functional household perspective was elaborated, with extra attention given to the organisation of activities and to the individual. Which role is applicable also depends upon the character of the reduction options: some had a more personal character, and others were applicable at the household level. Household determinants investigated, for instance, were 'influence of household members on laundering', Task Division, Combining of Tasks, and Frequency of Confer. Individual determinants were, for example, environmental awareness, knowledge, and motivation for changing or not changing. The issue for which an elaboration of the household perspective was most needed, with extra attention to the individual, was the acceptance of several changes at once. Because acceptance places demands on the household manager and on the organisation of household activities, the theory of Mental Accounting was applied to investigate and to explain whether several changes could be combined to form clusters. According to this theory, segregated negatively and positively valued changes are valued more highly than integrated losses and profits of the same magnitude. Acceptance of several changes can also be described using the Rogers' Diffusion of Innovations theory (1995)—extended by Moore (2000)—which explains the adoption rate of innovations through time, and for which two groups can be distinguished: the early market and the mainstream market. Activities and willingness to change were measured at a functional level and these data were aggregated to investigate the acceptance of several changes.

Case study of Textile Care

To investigate the acceptance of energy reduction options for the activity category Textile Care, a case study with oral interviews and quantitative questionnaires was held among 104 households in the province of Utrecht. Six specific energy reduction options were investigated: the use of a smaller washing machine, washing at lower temperatures, a gas-fired dryer, extra drying space, the use of cotton and polyester (CO/PE) blends for bedding, and more woollen clothing. For these options, the related practices were investigated, along with the reasons for laundering and for dryer use, as well as reasons for the willingness to change to these options. Other practices investigated were the use of e-buttons, loading of the washing machine and tumble dryer, spin drying, and clothing and bedding use. The willingness to change behaviour with regard to laundering, drying, textile material, and textile use was investigated as well.

An analysis was done to determine what activities constitute laundering. The most relevant behaviours within the laundering process were the wear and use of textiles and the number of days that textiles were used. The combination of demographic variables and textile use explained variations in the amount and composition of laundry. The combination of amount, composition, and planning determined which sorting method was used for the bulk of the laundry. This influenced the average wash temperature, the wash temperature of coloured laundry, sets of detergent use, and the total number of laundry types (general sorting). The latter influenced average load weight (but not the load weights of the bulk of the laundry) and the average number of hand washes, and consequently the washing frequency. The average washing machine and tumble dryer load weights were influenced by environmental awareness and opinions about careful maintenance, and through general sorting. Conscious ideas about specific behaviours were not reflected in the measured variance in these behaviours, such as wash frequency, way of loading, and space use. The combination of demographic variables, textile use, amount of laundry, and the planning of the laundering also influenced dryer possession, dryer use, and space use.
In short, laundering involved demographic factors that influence situational determinants as well as behavioural determinants that influence sequential behaviours (set 1). In this complex set of related practices and determinants, households should be able to find possibilities to change.

Answers to questions about reduction options contained distinctions. However, the aggregated willingness to accept the proposed reduction options was distributed normally. This indicated that the households' unique situations resulted in a different mix of choices. The aggregated willingness variable was significantly and negatively related to 'combining laundering with other tasks'. This variable reflected an organisational aspect; therefore, in the survey that followed, closer attention was paid to the acceptance of several options in relation to the organisation of household activities.

A factor analysis was done with variables for the willingness to accept, and with those that were most often related to these willingness variables (set 2). This set included demographic variables, practices, and opinions and attitudes. Eight factors were found (R^2=65 percent) that reflect the determinants of willingness to change at a functional level:

(1) A possibility to choose;
(2) A social status that influences laundering behaviour;
(3) The perception of a problem and the desire for a solution;
(4) Positive experiences with previous changes;
(5) The wish to keep practices as simple as possible, and the habit of doing so;
(6) Aspects that influence demand, such as household size;
(7) Heating of the space where laundry is line dried' (a variable on its own);
(8) Willingness to accept alternative solutions and unrelated reduction options.

These eight determinants explained the variation in willingness to accept energy-reducing laundering options at the functional level. The factors refer to general and abstract aspects and to characteristics of households and therefore it can be assumed that they are also relevant in other behavioural change issues. For behavioural change strategies, this means that, for example, focusing on attitude is not sufficient because other, practical factors within a complex set of related practices are at work as well.

One-third of the behaviour-option pairs (e.g. use time of clothes – longer use of clothes) were significantly related, with environmental awareness having scarcely any influence. From this it was expected that the other pairs were related in an indirect way. Determinants were searched for that were related to both behaviour and to the acceptance of reduction options. Significant relations can be used to form hypotheses about causality. This was done for six behaviour-option combinations (see the six mentioned specific reduction options) and for more broadly defined behaviour-option pairs (e.g. use time of clothes – lower wash temperatures). On the basis of these interrelated variables, suggestions for energy-friendly laundering behaviour could be formulated. Variables that were related more than once to one of the pairs formed a set (set 3). This set was compared with the set of variables that were related more than once to the behaviour variables (set 1); and to a set of variables that were related more than once to the willingness to accept variables (set 2). Of the 45 variables, 28 differ. Seven laundering indicators were formulated from these three sets: (1) amount of laundry; (2) earlier changes in wash temperatures; (3) dryer possession; (4) selective dryer use; (5) textile use (bedding type and material, wool use, use days, leaving clothes for some days); (6) space use, and (7) planning of laundering. These indicators describe the relevant issues of laundering, and so they offer an additional way to address energy reduction options and are opportune to use in communication about energy saving. The above-mentioned results demonstrated that determinants of willingness to change, of actual behaviour, and interrelated variables should be taken into account when behavioural change is addressed.

The energy-saving potential of the three most promising options (washing at lower temperatures, wearing clothes longer, line drying) represents 3-4 percent saving of the total (direct and indirect) energy needed for the laundering process.

Household organization and the acceptance of reduction options

The findings encouraged a further and more refined investigation into the willingness to accept a range of reduction options and about the influence of household task organisation. Concepts that measure aspects of household organisation were derived from the literature. These were Task Division, Combining of Tasks, Use of Household Help, Importance of Tasks, Perceived Time for Tasks, Home Production, Contracted Time, Commodity Use, Frequency of Confer, and Perceived Pleasure in Tasks. Further motivational (e.g. energy savings payback time, image, opinions of family members), limitative (e.g. time, money), operational (e.g. knowledge), and normative (e.g. environmental awareness) aspects were also inquired after. As in the case study, the actual performance of household activities that are related to the energy reduction options was investigated. This was done for 31 reduction options by way of a quantitative survey held among 376 households throughout the Netherlands. The reduction options addressed the activity categories House, Clothing, Food, Transport, Social Contacts, Leisure Time, and Large Purchases.

In a follow-up survey a year later the respondents were asked which of the 31 options had been considered, tried, and successfully implemented.

For each reduction option, the relation between behaviour and willingness to change was investigated in detail: For two-thirds of the reduction options, the actual behaviour was related to willingness to change.

- When *more* willingness to change was related to *less* energy-friendly behaviour, it concerned popular, impersonal, small, practical, and indoor practices, often repeated behaviours, which required little effort to begin and needed relatively low sacrifices in the use phase.
- When *more* willingness to change was related to *more* energy-friendly behaviour, it concerned personal preferences, which were less popular in general and were outward-oriented options.

The most promising options—because of their popularity and energy-saving potential—were (1) pre-rinsing with cold water in households that did not have a dishwasher; (2) using the tumble dryer more selectively; (3) heating 1°C less during the day when nobody is home and at night; (4) replacing flowers with plants and gifts; and (5) replacing pre-frozen vegetables with conserved vegetables in households that bought and stored frozen vegetables. Households that did not have energy-saving light bulbs were less willing to accept their use, whereas households that already had them were more willing to increase their use.

Functional activities were aggregated to a new variable, Use, which reflected the energy friendliness in actual practices. The willingness-to-accept-the-reduction-option variables were likewise aggregated to a new variable, Willingness. For these two variables, the respondents were divided into two groups, according to the theory of Moore (2000): a mainstream market (in theory 84 percent; referred to here as the *mainstream group*) and an early market (in theory 16 percent; referred to here as the *top group*). The mainstream group for Use consisted of 83 percent of the respondents; the mainstream group for Willingness consisted of 85 percent of the respondents. Use and Willingness were just slightly related in the mainstream group and stronger in the top group, suggesting that the two variables followed a different pattern and had different determinants, which indeed was the case. Using regression analyses it was determined which demographic, organisational, and environmental aspects played a role in the total sample, the mainstream, and top group for Use and Willingness. The energy friendliness (Use) of household behaviour was hampered by organisational factors:

(1) The respondent had a paid job (mainstream group);
(2) The use of commodities (total and mainstream group);
(3) The use of household help (total group);
(4) The frequency of confer (total and mainstream group).

Further, the education level of the respondent had a positive effect on energy friendliness (total and mainstream group), and whether the environment already played a role in household tasks had a positive effect as well (total sample), as did knowledge about the reduction options (total sample and top group). For Willingness, two organisational factors were influential:

(1) The number of times that household activities were combined (positive influence in total sample and top group; negative in the mainstream group);
(2) The frequency of confer on household tasks (a negative influence in the top group).

Willingness was further explained by whether the environment already played a role in household tasks (negative in the mainstream; positive in the top group), by the age of the respondent (negative in the mainstream group), by the number of children living at home (negative for the total sample; positive in the mainstream group), and by Use (positive in the top group).

- When more household activities were combined, it was related to lower education and lower age, and to a higher score on the importance of household tasks and a lower score on Willingness. This could indicate that household standards or results might not actually be higher but just that the respondent feels pressured or is aware that tasks have been combined. Possibly the number of combined activities are related to (1) skills in either shifting or performing complex routines; (2) mental accounting of groups of activities; (3) lack of practical intelligence to separate and organise sequential tasks; (4) how many household activities are undertaken, for which blocks of time and attention are reserved to reduce the feeling of pressure.
- A higher frequency of confer was related to job and work hours (being more often away from home) and to a more equal division of tasks, which indicates that fewer routines exist and that more activities need to be geared to each other. This requires discussion. Apparently routines are needed for space to accept changes in other fields of activity.
- Environmental awareness was not part of the regression solutions; instead, the more practical outcome of this psychological and abstract concept—'the environment plays a role in the performance of household tasks'—emerged.
- The positive effect of the number of children in the mainstream group—even within a sample with just family households—might be related to being flexible or to making concessions; to a positive, altruistic awareness of responsibility; or to a more structured, regular life in which further change is possible.

Thus, five different aspects of the household organisation played a role in Use and Willingness. Two aspects are relevant for both Use and Willingness. These are whether the environment already played a role in household tasks and the Frequency of Confer. For the top and mainstream group, three determinants of Willingness had a different influence. These variables are likely to be related to the threshold of what mainstream households can deal with (see also the differences in considerations) and provide information about the different character of the mainstream and top group.

If the clustering of options were possible, it might simplify measures to change household behaviour. The results were not promising. Factor analyses demonstrated that changing combinations of two to three options was possible. The fact that no clustering was observed can be explained in a number of ways. It is assumed that respondents chose reduction options which they liked or in which they perceived advantages for their household situation. According to the Mental Accounting theory, experiencing advantages is more pleasurable when they are spread over activity categories. Such a spread was found. Another explanation is that with ranges of losses in terms of money or effort judged in advance, people become more sensitive to the subsequent losses and therefore at least temporal spreading occurs. In addition, reduction options can simultaneously embody losses, costs, and advantages, and the evaluation of reduction options can vary for different groups of households. This was found for the mainstream and top group. In this study, explanations for the diverse outcome in which repeated options prevail were found in the familiarity of small, effortless options; in the situation of the household; and in differences between the mainstream and the top group in the evaluation and organisation of household activities.

How respondents evaluated the advantages and disadvantages of the reduction options was investigated as well. In general, households were divided in their opinion about the knowledge required for indirect options; for direct energy reduction options, the time and effort needed to acquire knowledge was not an important reason to consider. For indirect energy reduction options, the top and mainstream group (distinguished for Willingness) differed only in their estimation of what required more effort (top group: natural floor materials; mainstream: replacing cut flowers). For direct energy options, the top group was more in favour of use, image, and design aspects than was the mainstream group. These aspects were, for example, another type of light, the design of water-saving shower heads, and the opinions of other family members. Compared with the mainstream group, the top group had a neutral score more often and generally considered that these aspects were a reason to buy.

Follow-up survey

A year later it was investigated which of the energy reduction options had been considered, tried, and successfully applied. The follow-up survey was held among the general survey households and 62 percent returned the questionnaire: 62 percent of the mainstream group and 64 percent of the top group. The degree to which options had been considered, tried and successfully implemented was explained using variables from the general survey. To check whether households did what they had said, and to detect bias in self-reported change, two comparisons were made between the general and follow-up survey. Firstly, a comparison was made between the self-reported environmental friendliness of household behaviour in the follow-up survey and

the existing environmental friendliness of behaviour in the general survey. Secondly, a comparison was made between self-reported change in the follow-up survey and the willingness to accept in the general survey. For both comparisons, a slightly positive relation was found, indicating that at least the direction of what respondents claimed to have done could be trusted. The self-reported change in the follow-up survey was indeed influenced by the willingness to accept changes in the general survey. This led to the conclusion that intention eventually resulted in behavioural change. Older respondents were less willing to change—this emerged in the regression results of Willingness in the general survey as well as in the self-reported change in the follow-up survey—but the reason was not clear.
'Importance of household task results' and 'religion' emerged in the regression analyses in the follow-up but not in the general survey. It was concluded that these two factors caused (1) the difference between self-reported environmentally friendly behaviour (follow-up survey) and actual behaviour (general survey), and (2) the difference between a self-reported change in behaviour (follow-up survey) and the willingness to accept changes (general survey). In earlier research it was found that religion (measured in a general way) influenced the perception of one's self-reported moral behaviour but not one's actual behaviour. More generally, beliefs about behaviour influence the perception about actual behaviour rather than one's actual behaviour.

The options most often applied (by 19 percent of the respondents) were repeated behaviours (see Table B). The detailed data can be used to estimate the energy-saving potential in family households.

Table B One year later: the most frequently adopted energy reduction options

1. Energy-saving light bulbs	6. Holidays closer to home
2. Heat 1°C less	7. Selective use of tumble dryer
3. Gifts and plants instead of cut flowers	8. Washing at lower temperatures
4. Conserved i.s.o. frozen, imported, greenhouse vegetables	9. Using textiles longer
5. Driving less; more use of bicycles and mopeds	

The popularity of self-reported changes in repeated behaviours can be influenced by the fact that repeated routines are not registered in mental accounts and because small changes in routines are easily overvalued, which makes it easier to say that change occurred. However, households that enjoyed the general questionnaire and that had more available household time participated more often in the follow-up survey, which makes it likely that they actually did change behaviours to some extent. Furthermore, in earlier studies it was found that small, familiar options were applied first, and that was found in this research as well.
The most popular investments were water-saving shower heads, natural floor materials, a lighter car and energy-efficient appliances. On average, these were applied by 12 percent of the respondents. Most of the options that were related to investments or disinvestments were dropped. These options involved 'getting rid of, 'smaller capacity', requiring more time, money, or effort in use or to acquire.

A small number of repeated behaviours were also not modified. Either these options were being applied relatively often (cold pre-rinsing), were influenced relatively strongly by the family situation (meat), or the disadvantages weighed heavily (public transport, eco-flowers).

Conclusions and recommendations

In short, it can be concluded that a relation between behaviour, intention, and eventual change exists, but they have different patterns in the population—the relation varies for different reduction options, and for the mainstream and top group—and they have different sets of determinants. Among these are organisational household determinants and ones that point to the thresholds for the mainstream group compared with the top group.

Policy-makers keen to implement behavioural change programmes should expect small incremental changes per household. Change in household activities will often increase time use and complexity, which are only tolerable if other advantages prevail. These advantages are different for the mainstream and top group. General campaigns have scarcely any effect. Instead, feedback measures and information can help to change self-perception and increase knowledge, but adding in-depth coaching on changing routines and decreasing the complexity of household organisation or the perception of this complexity can probably result in a larger number and more lasting effects.

Determinants that were found in the case study and in the general and the follow-up survey should be taken into account when measures to change household behaviour in an energy-friendly direction are developed. There are indications that the self-reported changes and the perception of the environmental friendliness of actual behaviour are influenced by self-perception (through religiosity and the perception of the importance of household tasks). The willingness of the mainstream group to change to more options could be assisted by coaching. This would involve gaining a more realistic perception of the environmental friendliness of household practices and to what extent the environment already plays a role, as well as routinising household tasks and 'gearing' activity patterns; dealing with the pressure related to the number of combined tasks; and allowing for the positive influence of the number of children. Knowledge about reduction options would support energy-friendly household behaviour in general and in particular that of the top group.

In practice this means that three foundations must be laid to achieve behavioural change:

(1) Change the valuation of how the environment already plays a role in household tasks and change the perception of the energy friendliness of behaviour (relevant for both behaviour and willingness);

(2) Increase knowledge about behaviours that reduce energy consumption, in particular distinguished for daily routines vs. investments and disinvestments, and taking further into account indoor and outdoor activities, social and obligatory activities, and non-personal vs. personal and status-oriented options (relevant for behaviour, start with the top group);

(3) Reduce time constraints and complexity within households by coaching on routines and easy-choice options for investments (relevant for behaviour and willingness).

On a functional level and for specific activity categories sufficient possibilities for choice should be available, the perception of the problem needs to be mapped, experiences with earlier changes and the wish for simple solutions can be used, and the aspects that determine demand and that cannot be changed need to be taken into account. For segmenting the population, a division between the top and the mainstream group is relevant as well as social status (education, having a job) and age.

Strategies relating to knowledge and perception adjustment should distinguish for direct and indirect energy reduction options. The results of the investigation argue for different approaches to repeated behaviours, investments, and disinvestments. More attention is needed as to how investments in energy-friendly technology could be stimulated in households in a status quo situation. In particular for the mainstream group, in which time constraints and the desire for uncomplicated solutions prevail, an interface structure between households, local authorities, regulations, and markets could make it easier for them to invest.

The measurement of aspects of household organisation has been a first attempt and can be extended to increase knowledge about the functioning of households. Factors relevant for behavioural change included household organisational aspects, such as the number of combined activities and frequency of confer. Other determinants were the perception of behaviour compared with the actual household behaviour, the role of age and the number of children, and the role of education and knowledge of reduction options. Each of these factors had a different effect in the mainstream and the top group. The findings in this study are likely to apply to other important household-related fields as well, such as budgeting, combining work and childcare, and healthy lifestyles.

Samenvatting Energie en Huishoudens

Introductie

Antropogene broeikasemissies dragen bij aan het versterken van het broeikaseffect. Dit effect is een natuurlijk proces waarbij gassen in de atmosfeer infrarode straling absorberen. Toenemende concentraties van deze broeikasgassen zorgen ervoor dat er meer warmte wordt vastgehouden dan normaal. Een belangrijke bron van broeikasgassen is de verbranding van fossiele brandstoffen, die verbruikt worden voor elektriciteitsopwekking, voor transport en productieprocessen. Energieverbruik kan onderscheiden worden in directe energieconsumptie (gas, electriciteit) en indirecte energieconsumptie waarbij energie verbruikt wordt voor productie, distributie en handel van consumptiegoederen en diensten. Nederlandse huishoudens verbruiken 40-60 procent van het nationale energieverbruik, zelfs 70 procent wanneer sociale en collectieve diensten zoals gezondheidszorg meegerekend worden. Het huishouden kan gezien worden als de kleinste weergave van de consumptie- en productiemaatschappij Nederland BV (Nonhebel, 2000). Individuele consumenten, georganiseerd in huishoudens, hebben invloed op welke, hoeveel en op welke wijze goederen en diensten geproduceerd worden. Om energie te besparen zijn transities nodig op microniveau die een effect hebben op macroniveau. Van veranderingen aan de vraagkant van consumptiestructuren wordt verwacht dat deze de nationale lange-termijn energie reductiedoelstellingen ondersteunen.

Sinds de oliecrises aan het begin van de jaren '70 van de vorige eeuw, zijn eerst de publieke bezorgdheid ten aanzien van energie en later andere sociaalpsychologische factoren voor energiebesparend gedrag onderzocht. Vergeleken met gedragsverandering van het *individu*, zijn de invloed van de huishoudsituatie op energiebesparend gedrag en het uitvoeren en organiseren van functionele huishoudelijke activiteiten minder vaak onderzocht. Eerder onderzoek wijst uit dat ondanks dat mensen bereid zijn om energie te besparen en zich zorgen maken om het milieu, men maar weinig gedrag verandert. Voor dit proefschrift is onderzoek gedaan naar de invloed van de huishoudvoering op de bereidheid om energie reductieopties te accepteren. De algemene aanname dat intentie tot een gedragsverandering zal leiden is verlaten en in plaats daarvan is de relatie tussen het huidige gedrag en de intentie tot veranderen onderzocht. Dit omvat zowel de factoren die dit huidige gedrag bepalen, als de factoren die de bereidheid tot veranderen verklaren, zoals de uitvoering en organisatie van huishoudelijke taken.

Met het bestuderen van huishoudelijke activiteiten, kan de interactie tussen direct en indirect energieverbruik in detail onderzocht worden en wordt afwentelen vermeden. In een studie naar gedragsverandering van *huishoudens*, moeten verschillende aspecten in ogenschouw genomen worden, bijvoorbeeld de randvoorwaarden voor gedrag, de samenstelling van het huishouden en hoe welzijn in huishoudens door huishoudelijk gedrag wordt bereikt. De acceptatie van verandering en dus de uiteindelijke energiebesparingen zullen minder worden wanneer veranderingen niet binnen randvoorwaarden passen, tot een inefficiënt gebruik van huishoudelijke hulpbronnen leiden of het verzorgingsniveau verminderen.

De milieubelasting door huishoudens ontstaat op het niveau van huishoudelijke activiteiten (functioneel niveau), terwijl van het implementeren van meerdere veranderingen verwacht wordt dat dit organisatorische vaardigheden vergt. Daarom is het relevant zowel de uitvoering als organisatie van huishoudelijke activiteiten te onderzoeken. De algemene onderzoeksvraag was daarom:

> *Wat is de invloed van de huishoudvoering op de acceptatie en het energiebesparingspotentieel van broeikasgas reductieopties?*

Dit is onderzocht met behulp van verschillende onderzoeken: een casestudie met 6 energie reductieopties voor textiel en textielonderhoud; een algemene survey met een reeks van 31 reductieopties; een jaar later gevolgd door een follow-up survey waarmee de daadwerkelijke verandering is onderzocht.

Energiebesparingspotentieel

Tijdens het Leefstijl project (1990-1995) van het Nationaal Onderzoek Programma Mondiale Luchtverontreiniging en Klimaatverandering I, zijn de energie-inhouden van meer dan 350 huishoudelijke uitgavencategorieën van producten en diensten berekend, gebruik makend van een hybride methode waarin proces en input-output analyse gecombineerd zijn. Andere studies in het kader van dit project richtten zich op het differentiëren van leefstijlpatronen in uitgaven en energieverbruik van huishoudens maar dit bleek niet succesvol. Desondanks bleek dat de variatie binnen energieconsumptiecategorieën hoger is dan de variatie in het totale energieverbruik. Dit wijst op verschillen in consumptiepatronen. Daarom is het interessant om te onderzoeken of huishoudens hun indirecte energieverbruik ook kunnen veranderen. Reductieopties voor indirecte energie blijken gefragmenteerd en hebben een klein besparingspotentieel. Voor dit onderzoek zijn naast opties voor indirecte energie, ook reductieopties voor directe energie onderzocht omdat dan:

- de directe energieopties de potentiële besparing vergroten;
- vergelijkingen mogelijk worden tussen de acceptatie van directe en het indirecte reductieopties;
- het mogelijk wordt om de interactie tussen directe en indirecte opties te onderzoeken.

De gekozen reductieoptie categorieën staan in Tabel A.

Tabel A Categorieën van reductieopties

	Gebruik/gedragingen/gewoonten	Investeringen/aankopen
Direct energieverbruik	Stoken	Energiebesparende lampen
	Autogebruik	Zonneboiler
	Wastemperatuur**	Groene elektriciteit
	Wasmachine en drogergebruik**	Waterbesparende douchekoppen
	Afwas koud voorspoelen	Alternatieven voor apparatuur**
Indirect energieverbruik	Vakanties	Vloerbedekkingen
	Gebruik van textiel**	Snijbloemen
	Textielmaterialen*	Vlees (vervangen, vegetarisch)
		Groenten

** onderzocht in de casestudie; ** onderzocht in zowel de casestudie als de algemene survey*

Selectiecriteria waren dat het reductiepotentieel per optie tenminste 0.5 GigaJoule per huishouden per jaar is, en dat de totale set van opties over zowel activiteiten als investeringen en aankopen verdeeld is. Ook de directe beschikbaarheid voor huishoudens was van belang. Het theoretische energie besparingpotentieel van de opties (producten en activiteiten) is berekend met verschillende methoden, gebruik makend van nationale uitgavengemiddelden, nationale gebruikgemiddelden of per toepassing. De opties zijn aan 75 procent van de uitgavencategorieën en het totale huishoudelijke energieverbruik gerelateerd. Theoretisch is het besparingspotentieel van deze opties—inclusief interactie effecten—26 procent van het totaal (240 GJ). Het uiteindelijke huishoudelijke besparingspotentieel hangt af van het theoretisch potentieel, de acceptatie van huishoudens en de grootte van verandering op functioneel niveau.

Huishoudens en gedragsverandering

De bereidheid van huishoudens om de reductieopties te accepteren is onderzocht vanuit een functioneel huishoudwetenschappelijk perspectief. Dit perspectief richt zich op de functionele activiteiten in het huishoudsysteem. Deze activiteiten voorzien in het dagelijkse en het lange termijn welzijn van huishoudleden. Deze activiteiten bestaan uit productie, consumptie, verwerven van hulpbronnen, onderhoud, opslag, afdanken, besluitvorming en organisatie, waarbij (im)materiële hulpbronnen gebruikt worden en de levensstandaard als referentie dient. Dit alles hangt af van zowel de huishoudelijke situatie als van de invloed van de omgeving op huishoudens.

Het functioneel huishoudperspectief is uitgebreid met extra aandacht voor zowel de organisatie van activiteiten als voor het individu. Respondenten zijn niet alleen de vertegenwoordigers van het huishouden en de uitvoerders van huishoudelijke activiteiten maar ook de huishoudmanagers en de gatekeepers van veranderingen. In deze rollen zijn individuele determinanten van invloed. Welke rol van toepassing is hangt ook af van het karakter van de reductieopties: sommige opties hebben een meer persoonlijk karakter, terwijl andere opties op huishoudniveau van toepassing zijn. Huishoudelijke determinanten zijn bijvoorbeeld: 'invloed van huishoudleden op het wassen', taakverdeling tussen partners en het combineren van taken. Individuele determinanten zijn bijvoorbeeld milieubewustzijn, kennis en motivatie om (niet) te veranderen. Het onderwerp waarvoor uitbreiding van het huishoudperspectief met aandacht voor het individu vooral nodig was, was de acceptatie van verschillende veranderingen tegelijkertijd. Dit stelt eisen aan de huishoudmanager en aan de organisatie van huishoudelijke activiteiten. Om te onderzoeken en te verklaren of verschillende veranderingen gecombineerd kunnen worden in clusters, is de theorie van Mental Accounting toegepast. Volgens deze theorie delen mensen bij elkaar horende gedragingen in groepen in, en worden gesegregeerde negatieve en positieve veranderingen sterker gewaardeerd dan geaggregeerde verliezen en winsten van dezelfde grootte. Acceptatie van verschillende veranderingen kan ook beschreven worden met de Innovatie Diffusietheorie van Rogers (1995)—uitgebreid door Moore (2000)—waarmee de adoptiesnelheid van innovatie verklaard wordt en waarvoor twee groepen onderscheiden kunnen worden: de early market en de mainstream market. Activiteiten en bereidheid tot veranderen van deze activiteiten zijn gemeten op functioneel niveau en deze data zijn geaggregeerd om de acceptatie van verschillende energie reductieopties te onderzoeken.

Casestudie Textiel

Om de acceptatie van de energie reductieopties voor de activiteitencategorie Textiel te onderzoeken is een casestudie met mondelinge interviews en kwantitatieve vragenlijsten uitgevoerd onder 104 huishoudens in de provincie Utrecht. Zes specifieke opties zijn onderzocht: (1) een kleinere wasmachine, (2) op lagere temperaturen wassen, (3) een gas gestookte droger, (4) extra droogruimte, (5) het gebruik van katoen/polyestermengsels voor beddengoed en (6) meer wollen kleding. Voor deze opties zijn de gerelateerde activiteiten onderzocht maar ook het gebruik van energiebesparende knoppen en –programma's, belading van de wasmachine en droger, centrifugeren, gebruik van kleding en beddengoed, en de redenen voor wassen en drogergebruik. Ook de bereidheid om te veranderen met betrekking tot wassen, drogen, textielmateriaal en textielgebruik en de redenen daarvoor, zijn onderzocht.

Onderzocht is uit welke gedragingen de activiteitencategorie Textiel bestaat. De meest relevante gedragingen zijn het dragen en gebruiken van textiel en het aantal dagen dat textiel wordt gebruikt. De combinatie van demografische variabelen en textielgebruik verklaart de variatie in hoeveelheid en samenstelling van de hoeveelheid was. De combinatie van hoeveelheid, samenstellingen en planning van wassen bepaalt welke van de vijf sorteermethoden voor het sorteren van de 'bulk' van het wasgoed gebruikt wordt (bijvoorbeeld wit, licht gekleurd, donker gekleurd). Deze 'bulk' sorteermethoden beïnvloeden de gemiddelde wastemperatuur en daarmee het energieverbruik voor wassen, de wastemperatuur van gekleurde was, gebruikte sets van wasmiddelen, en het *totale* aantal wastypen dat onderscheiden wordt (sorteren in het algemeen). Dit laatste beïnvloedt gemiddelde belading (maar niet de beladingen van de bulk) en het aantal handwassen en daarmee de wasfrequentie. De gemiddelde beladingen van wasmachine en droger worden beïnvloed door milieubewustzijn en opvattingen over zorgvuldig onderhoud en door sorteren in het algemeen. Ideeën van de respondenten over *specifieke* gedragingen komen niet tot uiting in de gemeten variatie van deze gedragingen zoals de invloed op wasfrequentie, belading

en waargenomen ruimtetekort voor drogen. De combinatie van demografische variabelen, textielgebruik, de hoeveelheid was en planning van het wassen beïnvloedt ook het bezit en gebruik van de droger en het gebruik van ruimte.
In het kort zijn de determinanten van wassen dus (1) demografische variabelen die situationele determinanten beïnvloeden en (2) gedragsdeterminanten die opvolgende gedragingen beïnvloeden (set 1). Binnen deze complexe set van gerelateerde gedragingen en determinanten, zouden huishoudens ruimte moeten vinden om hun wasgedrag te veranderen om energiebesparing te bereiken.

De reductieopties worden in verschillende combinaties geaccepteerd. De geaggregeerde maat voor bereidheid tot accepteren van de reductieopties is normaal verdeeld. Dit wijst erop dat de unieke situatie van ieder huishouden resulteert in diverse keuzemixen. De geaggregeerde bereidheid was significant en negatief gerelateerd aan het combineren van wassen met andere huishoudelijke taken. Deze variabele geeft een aspect van de organisatie van taken weer. Daarom is in de volgende survey meer aandacht gegeven aan de acceptatie van meerdere opties in relatie tot de organisatie van huishoudelijke taken.

Met de variabelen voor bereidheid om te veranderen en de variabelen die hieraan het vaakst gerelateerd zijn (set 2) is een factor analyse gedaan. Set 2 bestond uit demografische variabelen, handelingen, meningen en attituden. Deze factor analyse resulteerde in acht factoren (R^2: 65%) die de determinanten van bereidheid om te veranderen op functioneel niveau weergeven:
(1) De mogelijkheid tot keuze;
(2) De sociale status en het gedrag dat er door beïnvloed wordt;
(3) Perceptie van een probleem en de wens voor een oplossing;
(4) Positieve ervaringen met eerdere veranderingen;
(5) De wens en gewoonte om gedragingen zo simpel mogelijk te houden;
(6) Aspecten die hoeveelheden (bv. wasfrequentie) beïnvloeden, zoals huishoudgrootte;
(7) 'Verwarmen van de ruimte waar wasgoed gedroogd wordt' (één variabele);
(8) Bereidheid om alternatieve oplossingen en ongerelateerde reductieopties te accepteren.
Deze acht determinanten verklaren de variatie in de bereidheid om energie reductieopties voor textiel te accepteren op functioneel niveau. De factoren verwijzen naar algemene en abstracte aspecten en karakteristieken van huishoudens en daarom kan aangenomen worden dat ze ook relevant zijn voor andere onderwerpen waarbij gedragsverandering een rol speelt. Voor gedragsveranderingstrategieën betekent dit bijvoorbeeld dat ingaan op attituden niet voldoende is omdat andere, praktische factoren in een complexe set van gerelateerde gedragingen een rol spelen.

Eén-derde van de gedrag-optie combinaties (bijvoorbeeld draagtijd van kleding – langer gebruik van kleding) zijn significant gerelateerd, waarbij milieubewustzijn nauwelijks invloed heeft. Verwacht wordt dat de andere combinaties op een indirecte manier gerelateerd zijn. Er is gezocht naar variabelen die zowel aan gedrag als aan de acceptatie-bereidheid zijn gerelateerd. Wanneer significante relaties gevonden worden kunnen die gebruikt worden om hypotheses over causaliteit te vormen. Dit is gedaan voor zes gedrag-optie combinaties (zie de zes genoemde specifieke reductieopties) en voor breder gedefinieerde gedrag-optie paren (bijvoorbeeld draagtijd van kleding – lagere wastemperaturen). Op basis van de geïnterrelateerde variabelen zijn suggesties gedaan die energievriendelijk wasgedrag kunnen ondersteunen. Geïnterrelateerde variabelen die meer dan eens voorkwamen vormen set 3. Deze set is vergeleken met de variabelen die meer dan eens aan de gedragsvariabelen gerelateerd zijn (set 1) en die meer dan eens aan de bereidheidvariabelen gerelateerd zijn (set 2). Van de 45 variabelen zijn er 28 verschillend. Op basis van deze drie sets zijn zeven wasindicatoren geformuleerd: (1) hoeveelheid was, (2) eerdere veranderingen in wastemperaturen, (3) drogerbezit, (4) selectief drogergebruik, (5) textielgebruik (type en materiaal van beddengoed, wol, gebruiksdagen, kleding laten liggen en weer dragen), (6) ruimtegebruik, (7) planning van wassen. Deze indicatoren beschrijven relevante aspecten van wassen. Deze bieden een alternatieve manier om energie reductieopties voor wassen te benaderen en kunnen gebruikt worden in de communicatie over energiebesparing. De bovengenoemde resultaten laten zien dat zowel de determinanten van bereidheid tot veranderen, als die van huidig gedrag, en de geïnterrelateerde variabelen van belang zijn wanneer gedragsverandering beoogd wordt.

Het energie reductiepotentieel van de drie meest belovende opties (op lagere temperaturen wassen, kleding langer dragen en drogen aan de lijn) beslaat 3 tot 4 procent van het totale (directe en indirecte) energieverbruik dat nodig is voor de activiteitencategorie Textiel.

Organisatie en acceptatie van reductieopties

De bevindingen van de casestudie zijn aanleiding geweest voor verder onderzoek naar de bereidheid om *meerdere* reductieopties te accepteren en de invloed hierop van de organisatie van huishoudelijke taken. Uit de literatuur zijn verschillende concepten afgeleid, die aspecten van de huishoudorganisatie meten. Deze concepten zijn: taakverdeling, combineren van taken, huishoudelijke hulp, belang van het resultaat, tijd voor huishoudelijke taken, huishoudelijke productie, tijd voor werk/verplichtingen, gebruik van apparatuur, overlegfrequentie en plezier in taken. Andere motivationele (bijvoorbeeld terugbetaaltijd, mening van huishoudleden), limitatieve (tijd, geld), operatieve (kennis) en normatieve (milieubewustzijn) determinanten zijn ook onderzocht. Net als in de casestudie is de uitvoering onderzocht van huishoudelijke activiteiten die gerelateerd zijn aan de energie reductieopties. Dit is gedaan voor 31 reductieopties met een kwantitatieve survey onder 376 huishoudens. De energie reductieopties hebben betrekking op de activiteitencategorieën Woning, Kleding, Voeding, Transport, Sociale contacten, Vrije tijd en Grote aankopen.

In de follow-up survey is onderzocht welke van de 31 opties zijn overwogen, geprobeerd en succesvol toegepast.

Voor elke reductieoptie is de relatie tussen gedrag en bereidheid om te veranderen in detail onderzocht. Voor twee-derde van de opties is het huidige gedrag gerelateerd aan de bereidheid om te veranderen.

- Wanneer *meer* bereidheid om te veranderen gerelateerd is aan *minder* energievriendelijk gedrag betreft dit populaire, onpersoonlijke, kleine, praktische, binnenshuis plaatsvindende, vaak herhalende gedragingen, die weinig moeite kosten om te beginnen en weinig opofferingen vergen tijdens de uitvoering.
- Wanneer *meer* bereidheid om te veranderen gerelateerd is aan *meer* energievriendelijk gedrag betreft dit persoonlijke voorkeuren, opties die minder populair in het algemeen en meer naar buiten gericht zijn. Wanneer een optie leuk gevonden wordt en al toegepast wordt, is het blijkbaar gemakkelijker om de toepassing uit te breiden, zelfs als dit moeite kost.

Op basis van de algemene survey zijn—vanwege hun populariteit en energie reductiepotentieel—de meest belovende opties: (1) met koud water de afwas voorspoelen door huishoudens die geen afwasmachine hebben, (2) selectiever gebruik van de wasdroger, (3) 1ºC lager stoken gedurende de dag wanneer er niemand thuis is en 's nachts, (4) het vervangen van snijbloemen door planten en cadeautjes, (5) vervangen van diepvriesgroenten door conservengroenten door huishoudens die diepvriesgroenten kopen en bewaren. Huishoudens die geen energiebesparende lampen hebben zijn minder bereid om deze te gaan gebruiken terwijl huishoudens die ze wel hebben bereid zijn om het gebruik uit te breiden.

De functionele activiteiten zijn geaggregeerd tot een nieuwe variabele (Use). Deze variabele geeft de mate van energievriendelijkheid in huishoudelijk gedrag weer. De bereidheid om opties te accepteren is op eenzelfde manier geaggregeerd (Willingness). Voor deze twee variabelen zijn de respondenten volgende de theorie van Moore (2000) in twee groepen verdeeld: een mainstream market (volgens Moore in theorie 84 procent, voor de resultaten van de algemene survey de mainstream groep genoemd) en de early market (in theorie 16 procent, hier de top groep genoemd). De mainstream groep voor Use bestaat uit 83 procent van de respondenten, de mainstream groep voor Willingness uit 85 procent van de respondenten. De mate van energievriendelijkheid in huishoudelijk gedrag (Use) en de mate van bereidheid 31 opties te accepteren (Willingness) zijn licht gerelateerd in de mainstream groep en sterker in de top groep, hetgeen suggereert dat deze variabelen een andere verdeling volgen en verschillende determinanten hebben, wat inderdaad gevonden is. Met regressie analyses is achterhaald welke demografische, huishoudorganisatorische en milieu aspecten een rol spelen in de totale steekproef, en in de mainstream en top groepen voor Use en Willingness. De energievriendelijkheid (Use) van huishoudelijk gedrag wordt belemmerd door de volgende organisatorische factoren:

(1) De respondent heeft een baan (mainstream groep);
(2) Het gebruik van apparatuur (totale steekproef en mainstream groep);
(3) Het gebruik maken van huishoudelijke hulp (totale steekproef);
(4) De frequentie van overleg over huishoudtaken (totale steekproef en mainstream groep).

Verder heeft het opleidingsniveau van de respondenten een positief effect op energievriendelijkheid (totale steekproef en mainstream groep), net als de kennis over reductieopties (totale steekproef en top groep) en of het milieu al een rol speelde in huishoudtaken (totale steekproef).

Voor de mate van bereidheid 31 opties te accepteren (Willingness) zijn twee organisatorische factoren van invloed:

(1) Het aantal keren dat huishoudelijke taken gecombineerd worden (positieve invloed in de totale steekproef en top groep; negatief in de mainstream groep);

(2) De frequentie van overleg over huishoudtaken (negatieve invloed in top groep).

De bereidheid wordt verder beïnvloed door of het milieu al een rol speelde in huishoudtaken (negatief in de mainstream; positief in de topgroep), door de leeftijd van de respondent (negatief in de mainstream groep), door het aantal kinderen (negatief in de totale steekproef, positief in de mainstream groep) en door Use (positief in de topgroep).

- Het vaker combineren van huishoudelijke taken is gerelateerd aan een lagere opleiding en een lagere leeftijd, aan het meer belang hechten aan het resultaat van taken, en aan een lagere score op Willingness. Dit kan er op wijzen dat de standaard of resultaten niet daadwerkelijk hoger liggen, maar dat de respondent meer druk voelt of zich meer bewust is dat taken gecombineerd worden. Mogelijk is het aantal gecombineerde activiteiten gerelateerd aan vaardigheden in verschuiven van aandacht of het uitvoeren van complexe routines; mentale boekhouding van groepen van activiteiten; of juist een gebrek aan praktische intelligentie om sequentiële taken te overzien, te scheiden en te organiseren.
- Meer overleg over huishoudtaken is gerelateerd aan het hebben van een baan en aan werkuren (meer van huis weg zijn) en een meer gelijke taakverdeling, hetgeen er op wijst dat er minder routines zijn en dat activiteiten op elkaar afgestemd moeten worden, waardoor er meer overlegd moet worden.
- Milieubewustzijn maakt geen deel uit van de regressieresultaten, in plaats daarvan kwam de meer praktische uitkomst van dit psychologische en abstracte concept naar voren, namelijk of het milieu een rol speelt bij de uitvoering van huishoudtaken.
- Het positieve effect van het aantal kinderen in de mainstream groep, zelfs binnen een steekproef met gezinshuishoudens, kan komen doordat men gewend is flexibel te zijn en concessies te doen, een positief en altruïstisch bewustzijn van verantwoordelijkheid heeft of men heeft een gestructureerd leven waarin meer verandering mogelijk is.

In totaal spelen dus vijf *verschillende* aspecten van de huishoudorganisatie een rol in de mate van energievriendelijkheid van huishoudelijk gedrag en de bereidheid om reductieopties te veranderen. Twee aspecten zijn relevant voor zowel de energievriendelijkheid van huishoudelijk gedrag als voor de bereidheid reductieopties te accepteren. Dit zijn of het milieu een rol speelt in de uitvoering van huishoudtaken, en in mindere mate de frequentie van overleg. Voor de bereidheid opties te accepteren is de invloed van drie determinanten in de mainstream en top groep tegengesteld. Deze determinanten wijzen vermoedelijk op drempels voor gedragsverandering voor huishoudens in de mainstream groep (zie ook de verschillen in overwegingen). Ook geeft deze bevinding informatie over het verschillende karakter van de mainstream en top groep.

Als clustering van reductieopties mogelijk is, kunnen maatregelen om huishoudelijk gedrag te veranderen, efficiënter toegepast worden. De aanwezigheid van clustering is onderzocht, maar de resultaten zijn niet veelbelovend. Factoranalyse laat zien dat verschillende combinaties van twee tot drie reductieopties mogelijk zijn. Dat er weinig mogelijkheden voor clustering zijn waargenomen kan op verschillende manieren verklaard worden. Respondenten zullen over het algemeen opties gekozen hebben waarin ze voordeel voor hun situatie zien of die ze leuk vinden.

Volgens de mentale boekhoudtheorie, geeft het ervaren van voordelen meer plezier wanneer deze verspreid worden over activiteiten categorieën en een dergelijke spreiding is gevonden. Een andere verklaring is dat bij reeksen van verliezen in termen van geld of moeite die van te voren beoordeeld worden, mensen gevoeliger worden voor de opeenvolgende verliezen waardoor spreiding in de tijd plaats vindt. Bovendien kunnen reductieopties tegelijkertijd verliezen, kosten en voordelen omvatten waardoor de evaluatie van reductieopties verschillend kan zijn voor diverse groepen huishoudens (zoals gevonden voor de mainstream en top groep). Verklaringen voor de diverse voorkeuren van huishoudens waarin herhalende gedragingen vooral populair zijn, zijn onder andere de bekendheid van kleine gemakkelijke opties, de situatie van het huishouden, de verschillen in karakter tussen mainstream en top groep en de organisatie van huishoudtaken.

De evaluatie van de voor- en nadelen van de reductieopties is ook onderzocht. In het algemeen zijn huishoudens verdeeld in hun mening over de hoeveelheid kennis die nodig is voor het beoordelen van indirecte energie reductieopties; voor directe energie reductieopties is de tijd en moeite om kennis te verkrijgen geen belangrijke overweging. Voor indirecte energieopties verschillen de top en mainstream groepen (onderscheiden voor Willingness) alleen in hun inschatting wat meer moeite kost (top groep: natuurlijke vloermaterialen; mainstream: vervangen van snijbloemen). Voor directe energie reductieopties is de top groep positiever over gebruik, image en design aspecten dan de mainstream groep, bijvoorbeeld over het type licht van energiebesparende lampen. De top groep heeft vaker een neutrale score of denken vaker dat deze aspecten een reden zijn om iets aan te schaffen, dan de mainstream groep.

Follow-up survey

Bij de huishoudens die meegedaan hebben aan de algemene survey is een jaar later onderzocht welke van de energie reductieopties overwogen, geprobeerd en succesvol toegepast zijn. Van deze huishoudens heeft 62 procent de follow-up vragenlijst teruggestuurd: 62 procent van de mainstream en 64 procent van de top groep. De mate waarin de energie reductieopties zijn overwogen, geprobeerd en succesvol zijn toegepast is verklaard met de variabelen uit de algemene survey. Om te checken of huishoudens ook doen wat ze zeggen en om een vertekend beeld in het zelfgerapporteerde gedrag te achterhalen, zijn twee vergelijkingen gemaakt. Eerst is de zelfgerapporteerde energievriendelijkheid van het huishoudgedrag in de follow-up survey vergeleken met de gemeten energievriendelijkheid van huishoudgedrag in de algemene survey. Ten tweede is de zelfgerapporteerde verandering in de follow-up survey vergeleken met de bereidheid om te veranderen in de algemene survey (Willingness). Voor beide vergelijkingen bestaat een licht positieve relatie, wat aangeeft dat ten minste de richting van wat de respondenten claimen klopt. De zelfgerapporteerde verandering in de follow-up survey bleek inderdaad beïnvloed te worden door de bereidheid om te veranderen zoals gemeten in de algemene survey. Dit leidt tot de conclusie dat intentie uiteindelijk tot gedragsverandering kan leiden. Oudere respondenten waren minder bereid om te veranderen—dit kwam naar voren in zowel de regressie resultaten voor bereidheid om te veranderen in de algemene survey als voor de zelfgerapporteerde verandering in de follow-up survey—maar de reden hiervoor is niet duidelijk.

Het belang van het resultaat van huishoudtaken en religie kwamen naar voren in de regressie analyses voor de follow-up survey maar niet in de algemene survey. Geconcludeerd is dat deze twee factoren respectievelijk het verschil veroorzaken tussen (1) zelfgerapporteerde energievriendelijkheid van huishoudgedrag (follow-up survey) en het bestaand gedrag (algemene survey), en (2) zelfgerapporteerde verandering in gedrag (follow-up survey) en de bereidheid om te veranderen (algemene survey). In eerder onderzoek is gevonden dat religie (in het algemeen) de perceptie van zelfgerapporteerd moreel gedrag beïnvloedt, maar niet het daadwerkelijke gedrag.

De reductieopties die het meest zijn toegepast (door 19 procent van de respondenten) zijn herhalende gedragingen (zie tabel B). De gedetailleerde data kunnen gebruikt worden om het energie besparingspotentieel in gezinshuishoudens te berekenen.

Tabel B Eén jaar later: de meest frequent aangenomen energie reductieopties

1. Energiebesparende lampen	6. Vakanties dichter bij huis
2. Eén graad lager stoken	7. Selectief drogergebruik
3. Cadeau's en planten in plaats van bloemen	8. Wassen op lagere temperaturen
4. Conserven in plaats van bevroren, geïmporteerde of kasgroenten	9. Textiel langer gebruiken
5. Minder met de auto rijden, vaker met fiets en brommer	

De populariteit van de zelfgerapporteerde herhalende gedragingen kan beïnvloed zijn doordat herhalende gedragingen niet geregistreerd worden in 'mental accounts' en doordat kleine veranderingen snel overgewaardeerd worden, wat het gemakkelijk maakt om te zeggen dat verandering heeft plaatsgevonden. Echter, huishoudens die de algemene vragenlijst leuk vonden en die meer tijd hadden hebben vaker meegedaan aan de follow-up survey, wat het aannemelijk maakt dat zij tot op zekere hoogte hun gedrag veranderd hebben. Bovendien is in eerder onderzoek gevonden dat kleine en bekende veranderingen als eerste toegepast worden, wat ook in dit onderzoek gevonden is.

De meest populaire investeringen zijn: waterbesparende douchekoppen, natuurlijke vloerbedekkingmaterialen, een lichtere auto, energie efficiëntere apparatuur, en niet vervangen van de vriezer. Gemiddeld zijn deze opties door 12 procent van de respondenten toegepast. Het merendeel van de opties die met investeringen of desinvesteringen te maken hebben worden niet als acceptabel gezien. Deze opties hebben betrekking op 'weg doen', 'kleinere capaciteit', of vergen meer tijd, geld, of moeite in het gebruik of om te verkrijgen. Een klein aantal herhalende gedragingen zijn ook niet veranderd. Deze opties zijn of al relatief vaak toegepast (koud de afwas voorspoelen), worden sterk beïnvloed door de familie situatie (vlees) of de nadelen wegen zwaar (openbaar vervoer, ecosnijbloemen).

Conclusies en aanbevelingen

Er bestaat dus een relatie tussen gedrag, intentie en uiteindelijke gedragsverandering, maar deze variabelen volgen verschillende patronen in een populatie—de relatie verschilt voor de diverse reductieopties en voor de mainstream en top groepen—en ze hebben verschillende determinanten. Daaronder zijn factoren die op functioneel niveau een rol spelen, huishoudorganisatorische determinanten en determinanten die op de drempels voor de mainstream groep wijzen.

Beleidsmakers die gedragsveranderingsprogramma's willen implementeren kunnen alleen kleine stapsgewijze veranderingen verwachten. Veranderingen in huishoudelijke activiteiten zullen vaak tot meer complexiteit leiden en tijd vergen, wat alleen acceptabel is als voordelen de overhand hebben. Deze voordelen zijn verschillend voor de mainstream en top groepen. Algemene campagnes hebben weinig effect. In plaats daarvan kan feedback en informatie helpen om de zelfperceptie te veranderen en kennis over reductieopties te vergroten, maar coaching ten aanzien van huishoudelijke routines en het verminderen van de complexiteit—of de perceptie hiervan—leidt waarschijnlijk tot grotere en blijvende effecten.

Bij het ontwikkelen van maatregelen voor gedragsverandering in huishoudens is het van belang om de determinanten te betrekken die in deze studie gevonden zijn. Er zijn aanwijzingen dat de gerapporteerde energievriendelijkheid van gedrag en veranderingen daarin beïnvloed worden door zelfperceptie (door religie en het belang dat aan het resultaat van huishoudelijke activiteiten gehecht wordt). De bereidheid van de *mainstream* groep om meerdere reductieopties aan te nemen zou gestimuleerd kunnen worden door coaching. Dit zou inhouden: (1) het verkrijgen van een realistischer beeld van de energievriendelijkheid van huishoudelijke gedragingen en de mate waarin het milieu al een rol speelt; (2) het routiniseren van huishoudelijke activiteiten en het op elkaar afstemmen van activiteitenpatronen; (3) het omgaan met de druk van het aantal (gecombineerde) huishoudelijke taken en (4) het benutten van de positieve invloed van het aantal kinderen. Kennis over reductieopties zal in het algemeen energievriendelijk gedrag ondersteunen en in het bijzonder dat van de top groep. In praktijk betekent dit dat om gedragsverandering te bewerkstelligen er drie funderingen gelegd moeten worden:

(1) Verbeter de perceptie en de waardering over in hoeverre het milieu al een rol speelt in het huishoudgedrag en de perceptie over de energievriendelijkheid van dat gedrag (van belang voor zowel gedrag als bereidheid om te veranderen);

(2) Verhoog de kennis over gedragingen die energieconsumptie verminderen, onderscheiden voor dagelijkse routines vs. investeringen en desinvesteringen, voor activiteiten binnens- en buitenshuis, voor sociale vs. verplichte activiteiten en voor persoonlijke statusgeoriënteerde vs. niet-persoonlijke reductieopties (van belang voor gedrag, begin met de topgroep);

(3) Verminder tijdsdruk en complexiteit in huishoudens door te coachen op routines en gemakkelijke investeringen (van belang voor zowel gedrag als bereidheid om te veranderen).

Op functioneel niveau en voor specifieke activiteiten categorieën zullen voldoende keuzemogelijkheden aanwezig moeten zijn, de perceptie van een probleem moet in kaart gebracht worden, er kan gebruik gemaakt worden van ervaringen met andere veranderingen en de wens voor gemakkelijke oplossingen, en er dient rekening gehouden te worden met niet-veranderbare aspecten die de energievraag beïnvloeden (zoals huishoudgrootte). Voor segmentatie van de populatie zijn top en mainstream groepen van belang alsmede sociale status (opleiding, baan) en leeftijd.
Voor strategieën om kennis en percepties te verbeteren, kan onderscheid gemaakt worden tussen directe en indirecte energie reductieopties. Bovendien pleiten de resultaten van deze studie voor verschillende benaderingen voor herhalende gedragingen, investeringen en desinvesteringen. Meer aandacht is nodig hoe investeringen bij huishoudens in een status quo situatie gestimuleerd kunnen worden. Met name voor de mainstream groep, waarvoor tijdsdruk en de wens voor ongecompliceerde oplossingen een rol spelen, kan een structuur tussen huishoudens, (lokale) autoriteiten en markt het gemakkelijker maken om te investeren, informatie te laten doorstromen en contacten te bewerkstelligen.

Het bepalen van de invloed van organisatorische aspecten van de huishoudvoering op mogelijkheden voor gedragsverandering is een eerste poging geweest en kan uitgebreid worden om kennis over huishoudens te vergroten. Relevante organisatorische factoren voor gedragsverandering zijn bijvoorbeeld het aantal gecombineerde taken en frequentie van overleg. Andere determinanten zijn de perceptie van gedrag, leeftijd en aantal kinderen, opleiding en kennis van reductieopties. Elk van deze factoren heeft een ander effect in de mainstream en topgroepen. De gevonden resultaten zijn waarschijnlijk ook van toepassing bij andere onderwerpen die voor huishoudens van belang zijn en gedragsverandering van huishoudens vragen, zoals als het omgaan met financieën, het combineren van werk en zorg voor kinderen, en het bereiken van een gezonde leefstijl.

Curriculum Vitae

Diana Erica Uitdenbogerd was born on February 17, 1968, in Haverford West, Great Britain, and spent her first two-and-a-half years at Orielton, Castlemartin Peninsula, Pembrokeshire, before moving with her family to the Netherlands. In 1986, she completed the first stage of her secondary education (HAVO) at the St. Laurenscollege in Rotterdam, followed by the second stage in 1988 (VWO).

From 1988 to 1994 she studied Household and Consumer Sciences at Wageningen Agricultural University. As part of her studies she worked in 1992 at the Women's Environmental Network in London on a briefing about energy-sound behaviour in households and on exhibition material for the 1992 Rio Janeiro UNEP meeting. One master's thesis, 'Nappy systems: choice and influence on household keeping', was completed at Wageningen University in 1993. A second master's thesis, 'Energy Requirement of Food Provision in Households', was completed in 1994 at ECN, the Dutch Energy Research Centre in Petten. She graduated in 1994 with household technology and environment as her major subject.

In 1995 she became a PhD student, employed by the Dutch Organisation for Scientific Research (NWO), based at the former department of Household and Consumer Studies of Wageningen Agricultural University, currently the sub-department of Consumer Technology and Product Use at Wageningen University and Research Centre. From 1995-2000, Diana participated in courses offered through the research school SENSE (Socio-Economic and Natural Sciences of the Environment). She presented papers about her research at conferences of the International Federation of Home Economics (Scotland, 1997; Finland, 1998), at the Second International Symposium on Sustainable Household Consumption (Netherlands, 1999), at Global Warming and Expo conferences (Japan, 1999; USA, 2000), the conference for Greenhouse Gas Control Technologies (Australia, 2000) and for Novem on similar topics at a workshop for the revision of the European Energy Label for washing machines (Italy, 2000) and the ECEEE conference (France, 2001).

From 2000 to 2002, she worked at Novem B.V., the Dutch Energy Agency, on programmes regarding consumer behaviour in relation to energy. At Wageningen University and at Novem she guided students who were working on their master's theses. Following a two-year break, she returned to research and has been conducting studies on literature relating to household and energy issues for SenterNovem, Klinckenberg Consultants, ResCon, and the ministry of Housing, Spacial Planning, and the Environment.

The SENSE Research School declares that Ms. Diana Erica Uitdenbogerd has successfully fulfilled all requirements of the Educational PhD Programme of SENSE with a work load of 39 ECTS, including the following activities:

SENSE PhD courses:

- Environmental Research in Context
- Research Context Activity: "Contribution to discussions on aspects of energy saving in SenterNovem and media release on dissertation research"
- Global Change: Land Use, Energy and Climate Change
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