Summary

1 Introduction

Humans in households use energy for their activities. This use is both direct, for example electricity and natural gas, but also indirect, for the production, transport and trade of other goods and services. The availability of energy allows many people in industrialised countries to enjoy a consumption level with unprecedented comfort and mobility. The World Energy Assessment concludes that today's energy system is not sustainable. This is due to environmental, economic and geopolitical concerns, all having implications far into the future. A sustainable energy system is important for keeping the major benefits of the use of energy in the future. There are various ways to achieve a more sustainable energy system, but the change of consumption patterns is an under-explored option. Since changes in consumption patterns can lead to a reduction or limitation in the energy requirement of society, thus contributing to a more sustainable world, the analyses presented in this thesis should be helpful in exploring the feasibility of this option.

The main objective of this thesis is to gain insight into the energy requirement associated with household consumption patterns, with a focus on (I) the quantification of the energy requirement of the present consumption pattern and its components, (II) differences in the energy requirement between groups of households and, (III) the development of the average consumption pattern in the past and future. Insight into the energy requirement associated with household consumption patterns is necessary before an answer can be given to the question on how the energy requirement caused by consumption can be decreased by changing consumption patterns.

The energy requirement of society was examined here from the household perspective. In fact, in the end all products and services produced within an economic system are meant for consumption, mainly by households. Determining the energy requirement associated with consumption patterns and the differences between consumption patterns required an alternative cross-section of the economy as opposed to the traditional sector-by-sector approach. All energy required by society has been allocated to the products consumed by consumers, living mainly in households. A fast and accurate method was needed for analysing the primary energy requirement of many individual consumption categories.

2 ► Determining the primary energy requirement of consumption patterns

Chapter 2 proposes a hybrid method to analyse the primary energy requirement for the various consumption categories. There are two common ways to calculate the energy requirement of a consumer good. The first is input-output analysis, which is not very accurate but does allow one to rapidly calculate the energy requirement of all consumer goods. The second is process analysis, which is very accurate but requires a lot of input data. The hybrid method for energy analysis as presented in Chapter 2 combines the accuracy of process analysis with the speed of input-output analysis.

This hybrid method for energy analysis was found to be suitable for rapidly calculating the direct and indirect energy requirement associated with the purchase and use of large numbers of consumer goods. The method detects differences between consumption categories, even if they are produced by the same economic sector. For individual products, of which the price level deviates from the mean price, the use of input–output analysis for parts of the calculations can cause errors. However, on average, the calculated energy requirement will be correct. Although the error margins for individual products can be reduced by using more process data, more effort will be needed to make analyses.

3 ► The energy requirement of cut flowers and consumer options to reduce it

We first applied the hybrid method for energy analysis to one component of the consumption pattern: cut flowers. In 1990, an average Dutch household purchased one or more bouquets of flowers for €88[1] at a frequency of 11 times throughout the year; this came to a total of about 250 flowers. Together these flowers required about 2.2 GJ, or about 1% of the total primary household energy requirement. The energy intensity of flowers is among the highest of all non-energy household purchases: on average about 25 MJ/€. The high energy intensity of cut flowers makes it interesting to take a closer look at less energy-intensive alternatives.

The aim of Chapter 3 is to examine how households can reduce their primary energy requirement for the decorative and gift functions provided so far by cut flowers, taking the financial costs into account. First, the cumulative primary energy requirement for 37 of the most common cut flowers grown in the Netherlands was determined as a function of the season of purchase. The energy requirement and energy intensity varied considerably per month of purchase and per type of flower. Large variations were found in the energy requirement per flower, ranging from 3 to 195 MJ. The functionality of cut flowers was then elaborated, as this is relevant to the degree to which alternatives are feasible. After this, several options for the reduction of the energy required were worked out. A distinction was made between replacements by other types of products of the same category and other types of products with a comparable function. All reduction options can be applied nowadays by households. Examples are: replacing flowers as a gift by other articles, using flowering indoor plants instead of cut-flowers and buying less energy-intensive flowers like flowers from abroad, less energy-intensive species and flowers in summertime.

1 In the various chapters of this thesis, monetary results have been provided in currencies for various years, both in Dutch guilders (Dfl.) and Euros. In this summary all monetary results have been converted to the Euro-equivalent of the 1995 guilders (using the exchange rate at the guilder-Euro conversion: €1 = Dfl 2.20371). Further, we used the conversion factor: 1 Dfl_{1990} = 1.14 Dfl_{1995}, from the website of Statistics Netherlands (www.cbs.nl).

The analysis in Chapter 3 suggests that if all the consumer energy reduction options discussed here are applied to a substantial extent, the cumulative energy requirement for flowers and their substitutes for Dutch households can be halved. The findings in Chapter 3 can certainly not be extrapolated to other consumption categories, be it only because of the extremely high energy intensity of cut flowers. This analysis shows a variety of options that together have substantial potential for reducing the primary energy requirement. However, it is this variety that makes achieving this potential difficult.

4 ► The direct and indirect energy requirements of Dutch households

Chapter 4 aims to overview the total energy requirements of Dutch households and the energy requirement of about 350 consumption categories, including an outline of the influence of several important variables determining the total energy requirement of consumption: net household income, household expenditure, age and number of household members. In realising this aim, the energy intensities of all 350 consumption categories were determined using the hybrid method for energy analysis (see Chapter 2). Next, the energy requirements of Dutch households were calculated by combining the 350 energy intensities with expenditure data from 2767 households. Data were collected by National Statistics in the Household Expenditure Survey of 1990.

We found large differences in the energy intensities between the 350 consumption categories, varying from about 2 MJ/€ for services (for instance repairs, hiring a cab, the nursery) to about 111 MJ/€ for natural gas. The average energy intensity for the energy carriers was found to be about 88 MJ/€, while the average energy intensity for all other products and services was found to be about 7 MJ/€. The average energy intensity for the whole consumption pattern in 1990 amounted to about 12 MJ/€.

The total average energy requirement in the Netherlands in 1990 was found to be 240 GJ per household, or 99 GJ per capita, of which 54% was indirect (see Figure S-1). Among the analysed socio-economic variables, the net income was found to have the most important relationship with the total energy requirement. The elasticity of the energy requirement with respect to income came to 0.63. There is, however, a considerable spread in energy requirement within a particular income class (standard deviation about 20%). A one-person household requires about 45 GJ less energy than a multiple-person household with the same income level. No differences in the total energy requirement were found between households from different age groups.

The important relationship between income and total energy requirement suggests that, with further increases in income levels, the average household energy requirement will probably rise as well. However, the large differences between the energy intensities of the various consumption categories indicate that the total household energy requirement can be reduced by changing the consumption pattern. The substantial spread in the total energy requirement of households within the same income class also supports this.

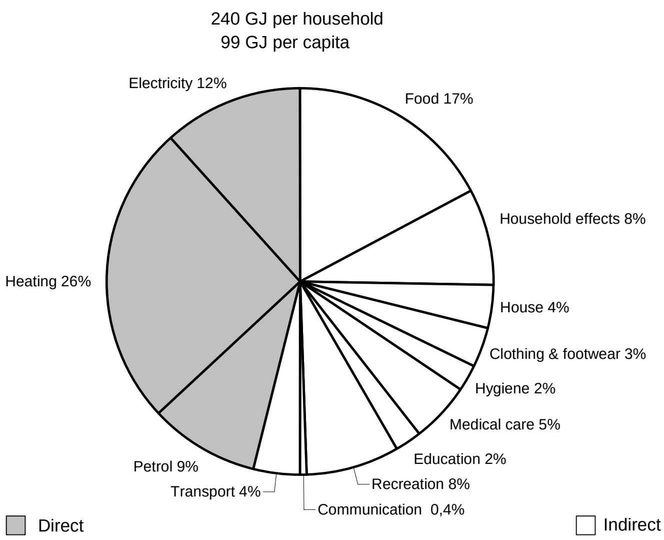

Figure S-1 The average total (direct plus indirect) energy requirement per household or capita in 1990, split up into main consumption categories.

5 ► Household energy requirement and value patterns

As mentioned above, the net income was found to have the most important relationship with the total energy requirement. But the net income cannot explain all the variance in the total energy requirement, not even in combination with other socio-economic parameters such as household size, education level and age. For an efficient consumer energy policy it is important to know why some households require more energy than others.

The differences in the total household energy requirement can be described as differences in consumer behaviour. Many studies indicate that many factors influence the actual consumption behaviour. One often mentioned factor possibly influencing consumer behaviour is people’s value pattern. The aim of Chapter 5 is to examine whether there is a relationship between the total household energy requirement and value patterns. Besides value patterns, two other non-socio-economic characteristics were examined as well; these could be expected to influence behaviour more directly than values do. These were: (I) the motivation to save energy and (II) the perception of energy-related societal problems.

These relationships were examined via a survey on consumption among 2304 household respondents. The actual total consumption pattern and the accompanying energy requirement for the respondent households were determined from this survey. To compare the energy requirement of a specific household with the energy requirement of other households having the same socio-economic characteristics, a reference energy requirement was calculated. The reference energy requirement depends only on the socio-economic characteristics.

Despite a detailed calculation of the energy requirement of individual consumption patterns, we could not find that the energy requirements of one of the groups examined for value patterns or problem perception level of climate change significantly differed from the rest. Here we took into account the differences in the socio-economic situation of households. Only for the motivation to save energy we did find that the least motivated group requires 10 GJ more energy than the average and most motivated groups; this is about 4% of the total energy requirement. The lack of a relationship between the total household energy requirement and values, as well as the perception of the climate change problem or the motivation to save energy, means that an energy policy solely based on a strategy of internalising environmental responsibility will not be effective in saving energy. There are indications that a social dilemma is one of the reasons why people do not consume according to their value patterns, problem perception or motivation to save energy.

6 ► Long-term trends in direct and indirect household energy intensities

More knowledge about developments in consumption patterns in the past may improve our understanding of the ways consumption patterns could develop in the future. The aim of this chapter is to analyse consumption patterns of Dutch households in the past, so as to discover changes in the average consumption pattern and its energy intensity.

To determine the direct and indirect (cumulative) energy requirements of household expenditure, Dutch household consumption data were used for the period from 1948 to 1996. Because we are specifically interested in the changes in the energy requirement caused by changes in consumer behaviour, energy intensities frozen at the 1990 level were used to calculate the energy requirement. In doing so, energy intensity changes (for instance, those caused by efficiency improvements) of the supplying sectors (industrial, transport and distribution) were excluded from the analysis. Also, the resulting energy requirement was corrected for climate fluctuations.

As a result of a rise in consumption level the total household energy requirement per capita in the Netherlands grew between 1948 and 1996 by about 2.4% per year (see Figure S-2). In this period changes in household consumption patterns led to a net growth in the total energy intensity, from 12 to 14 MJ/€ (about 0.25% per year), with some fluctuations. The share of the direct energy requirement in the total household energy requirement is the main determinant of both the fluctuations and the net growth. Without energy efficiency improvements for heating the house and for electrical equipment, the growth of the total energy intensity would have been substantial higher. Between 1948 and 1996 the indirect energy intensity only

declined slightly from 8.4 to 7.9 MJ/€ (about 0.14% per year). The main reason for this reduction was the decrease in the share of the energy requirement for food.
Thus it can be concluded that the average consumption pattern of households in the Netherlands in the past five decades did not show a substantial development towards a lower energy intensity. This indicates that a change to a consumption pattern with a lower energy intensity did not occur in the Netherlands.

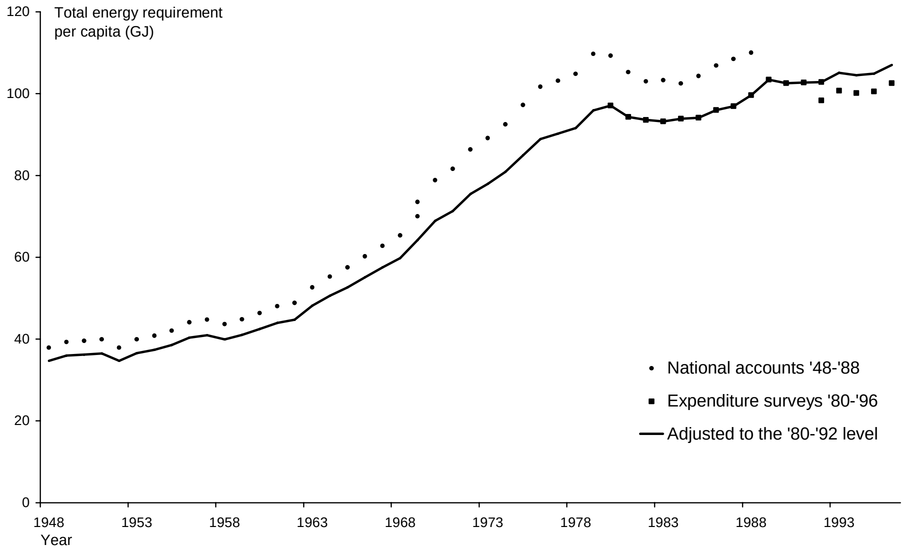

Figure S-2 The total energy requirement per capita for 1948 to 1996, calculated with fixed energy intensities of 1990. Different data sources were used. The solid line shows the adjusted energy requirement, to one common level.

7 ► Long-term scenarios for the direct and indirect energy requirement of Dutch consumers

Besides knowledge about changes in consumption patterns in the past, it is also important to have information on possible autonomous future changes in the consumption pattern and the accompanying energy requirement. The aim of Chapter 7 is to estimate the composition of the consumption pattern in 2030 and the accompanying energy requirement, distinguishing the effects of the most important forces which can have influence on the consumption pattern.

A method was developed to be able to estimate a complete future consumption pattern on a detailed level. The method derives the expected consumption pattern from driving forces that affect consumer decisions. Apart from economic changes, non-economic driving forces such as technical and demographic changes, and changes in consumer purchasing behaviour, were taken explicitly into account. The method takes the effects of each driving force separately into account with the help of an appropriate approach for each driving force concerned.

The total primary energy requirement for consumption per capita was estimated for the year 2030 for two business-as-usual scenarios (European Co-ordination - EC and Global Competition - GC). In these scenarios, between 1995 and 2030 private consumption increases by 120% (EC) and 180% (GC) per capita, while the required primary energy is expected to increase by 30% and 60%, respectively. This is an annual growth of 0.8% and 1.3% of the energy requirement per capita, respectively. The relative shares of the consumption domains food, dwelling and clothing decrease while the relative shares of the domains household effects, holidays, leisure indoor and leisure outdoors increase. The energy requirement for the dwelling is the only domain that is expected to decrease in absolute terms. The indirect energy requirement becomes more important; its share increases from about 50% in 1995 to two-thirds in 2030. In the two scenarios the total energy intensity of the consumption pattern will decrease by 40% (-1.5% per year). This expected reduction indicates a relative de-linking of consumption from the energy requirement for consumption.

Two-thirds of the reduction in the energy intensity between 1995 and 2030 is due to changes in energy efficiency of consumer goods and changes in energy efficiency of the production of the consumer goods. A third driving force, formed by changes in consumer purchasing behaviour, is responsible for the remaining one-third reduction in the energy intensity caused by a relatively low growth in the energy intensive fuels for transport, heating the dwelling and the production of hot water. The driving forces, ‘economic changes’ and ‘demographic changes’, hardly affect the energy intensity.

The decreasing energy intensity for the 1995-2030 period contrasts with the nearly stable energy intensity found in Chapter 6 for the period between 1948 and 1996. This difference can partially be explained by the exclusion of the efficiency improvements in the supplying sectors in Chapter 6 and the inclusion of these improvements in Chapter 7. The rest of the explanation can be found in the relatively low growth in the direct energy requirement between 1995 and 2030 and the relative high growth in the direct energy requirement between 1962 and 1975. After 1975 the energy intensity already started to decrease slightly, due to a decrease in the share of the direct energy requirement.

According to the two analysed scenarios the reduction in energy intensity does not lead to an absolute reduction in the required primary energy caused by private consumption. This is due to the expected growth of expenditures for consumption, particularly because the net income grows.

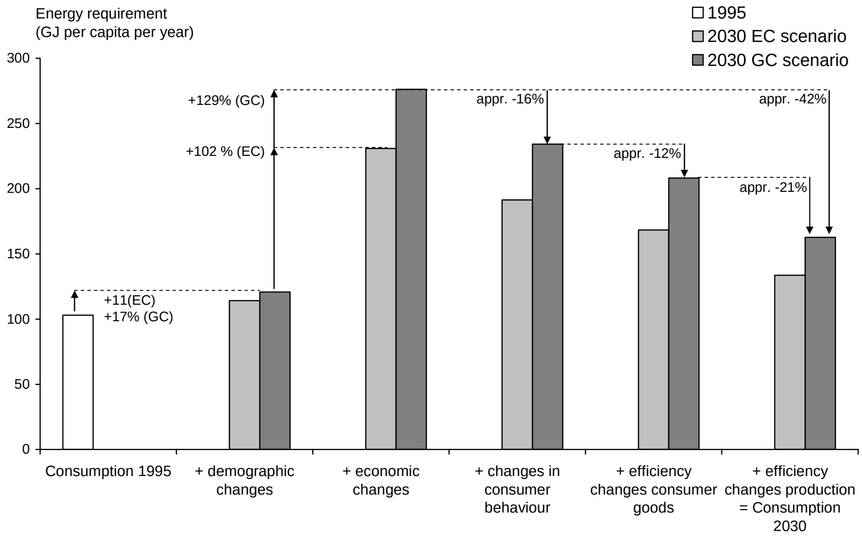

Figure S-3 Energy requirement for private consumption per driving force and per capita in the years 1995 and 2030 for the EC and GC scenario.

8 ► Final comments

The analyses in this thesis should be helpful in exploring the feasibility of the option to reduce or limit the energy requirement of society by changing consumption patterns.

The results in the Chapters 3 and 4 indicate that changing consumption patterns can reduce or limit the energy requirement of society. There are large differences between the energy intensities of consumption categories. Also the spread in energy requirement of households within the same socio-economic situation was found to be large.

However, the results in the Chapters 6 and 7 indicate that a change in consumption patterns (to reduce or limit the energy requirement of society), will not occur autonomously. No substantial trend towards a less energy intensive consumption pattern has been found for the past decades (excluding efficiency improvements in industry and retail). Chapter 7 suggests that, in the future, an autonomous substantial reduction of the energy intensity will occur, but the ongoing economic growth will still lead to a higher household energy requirement.

These findings are combined with the lack of any influence of values, problem perception and motivation on the household energy requirement, as found in Chapter 5. Then, it is clear that it will not be easy to reduce household energy requirements. A really strong policy that solves the social dilemma aspect of the problem, for instance, via pricing or regulation, will be necessary to achieve a reduction in the energy requirement of society through changes in household consumption patterns.