Chapter 6

Long-term trends in direct and indirect household energy intensities: a factor in dematerialisation?[1]

► Abstract

Dematerialisation is assumed to contribute significantly to the alleviation of environmental problems. One of the possible causes of dematerialisation is a change in the consumption patterns of households. The aim of this chapter is to analyse changes in the consumption patterns of Dutch households in the period between 1948 and 1996 to discover whether these changes have influenced the energy intensity of society. The rise in consumption has caused the total household energy requirement per capita to increase by an average of 2.4% per year over a period of 48 years (this figure ignores efficiency changes in the supply sectors). In the same period the total energy intensity of households fluctuated but, on average, did rise from 5.6 to 6.3 MJ/Dfl., representing an increase of 0.25% per year. Excluding the direct energy consumption, we find only a slight decline in the indirect energy intensity, namely, from 3.8 to 3.6 MJ/Dfl. (-0.14% per year). No significant trends towards a lower energy intensity were found; neither was there any indication of dematerialisation of the consumption patterns. If governments are to pursue a policy of sustainable development they will have to take into account the fact that dematerialisation of the consumption pattern does not seem to be an autonomous process.

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1 This study is a slightly adapted version of Vringer, K. and Blok, K. 'Long-term trends in direct and indirect household energy intensities: a factor in dematerialisation?', *Energy Policy*, 28 (2000): 713-727.

1 ► Introduction

In the past decade various analysts have focused on the phenomenon of dematerialisation. Dematerialisation can be defined as 'the reduction in the raw material (energy and material) intensity of economic activities, measured as the ratio of energy consumption in physical terms to the gross domestic product (GDP) in deflated constant terms' (Bernardini and Galli, 1993). There was a reduction in the raw material and/or energy intensity with respect to various materials, e.g. crude steel, copper and zinc, in world regions with a level of GDP per capita higher than US$2000 (Bernardini and Galli, 1993). The reduction was also observed for energy consumption in most countries (Nakicenovic and John, 1991; IEA, 1997).

Dematerialisation is assumed to contribute significantly to the alleviation of environmental problems or to contribute at least to the easing of conflicts between the economy and the environment (Wieringa et al., 1992). If the process of dematerialisation is so important, more should be found out about its underlying causes. Wieringa et al. (1992) suggest some possible causes of dematerialisation:

- changes in the composition of products (more emphasis on quality and design);
- changes in consumption patterns (from material-intensive to labour-intensive products and services);
- technical developments (leading towards more efficient use of energy and materials) and
- changes in the import/export structure (these changes can only cause a regional change in the material intensity, but not a worldwide change).

Not much is known about the importance of each of these factors for dematerialisation at national level. Studies have shown that technical developments play a role in the decrease in energy intensities: the specific energy consumption of many activities in industry, buildings and transport has decreased in many countries (e.g. Schipper and Meyers, 1992; Eichhammer and Mannsbart, 1997; Farla et al., 1997; IEA, 1997; Farla et al., 1998).

In this chapter we focus on one of the other causes: changes in consumption patterns. Consumption patterns of households are to a large extent decisive for the total requirement for goods and services and hence the activity levels of economic sectors. The aim of this chapter then is to examine whether past changes in

consumption patterns have influenced the dematerialisation of society. We will limit ourselves to one important resource, energy. The question is therefore whether changes in household consumption patterns have led to decreasing energy intensity in society. We will investigate this by studying the effect that changes in household consumption patterns in the Netherlands have on the life cycle energy requirement (embodied energy) of the products and services consumed by households.

Here, we first describe the method, data sources and the way of calculating the total energy requirement of households. This will be followed by the results concerning general trends, the direct, indirect and total household energy requirements and the energy intensity of household consumption. We will draw some conclusions after discussing the quality of the results.

2 ► Method and data

We start by discussing the definitions of the most important concepts and will follow this with showing how the direct and indirect (cumulative) energy requirements of households are determined. We define:

- *Direct household energy requirement*, as the total primary energy required to produce the energy carriers which households consume (petrol, electricity, natural gas and heat).
- *Indirect household energy requirement*, as the total primary energy required to produce all the other products and services which households consume.
- *Total household energy requirement*, as the sum of the direct and indirect household energy requirements.
- *Energy intensity* of a product, as the total primary energy requirement of the product divided by the consumer price of the product (incl. VAT). The energy intensity is expressed in MJ/Dfl.[2]. In the same way the energy intensity of a group of products or the energy intensity of all household expenditures can be calculated (Vringer and Blok, 1995).

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2 All monetary quantities are expressed in Dutch guilders (Dfl.) of 1995. One Dfl. is about 0.45 Euro or 0.6 US$ (1995).

If both the expenditure and the energy intensity of all the consumption categories are known, the total household energy requirements can be calculated according to the following equation:

$$E = \sum_{i=1}^{n} \varepsilon_i * S_i$$

where:

E = total household energy requirement
ε_i = energy intensity of consumption category i
n = number of consumption categories
S_i = expenditure on consumption category i

To calculate the total energy requirement for a specific year we need to have both expenditure and energy intensity data for that year:

$$E_t = \sum_{i=1}^{n} \varepsilon_{i,t} * S_{i,t}$$

in which the suffix t denotes that data are valid for a specific year t.

However, we are specifically interested in the changes in the energy requirement caused by a shift in the consumption package. To investigate these changes, we used fixed energy intensities *frozen at the1990 level*. By doing so, we exclude energy intensity changes (probably mainly efficiency improvements) of the supply sectors (industrial, transport and distribution) from the analysis. The energy requirement with energy intensities frozen at the level of 1990, can be calculated according to the following equation:

$$\hat{E}_t = \sum_{i=1}^{n} \varepsilon_{t,1990} * S_{i,t}$$

in which $\hat{E}_t$ is the total energy requirement of households at fixed 1990 energy intensities. The data for the energy intensities of 1990 are available from a previous study (Vringer and Blok, 1995). The sources needed for the annual expenditure data

are described in the next section and the expenditures given per household. The total energy requirement can be expressed for all households or per capita[3].

In time-series analysis it is important to correct for climate fluctuations. The household energy requirement for heating (assumed to be 85% of the requirement of natural gas, coal and fuel oil[4], Zonneveld, 1993) is multiplied by a climate correction factor. We calculated this factor by dividing the specific number of degree days for the year concerned by the average annual number of degree days between 1945 and 1993 (Sypkens-Smit, 1993; Farla, 1997).

3 ► Expenditure data

For the time-series of the household expenditure data, we used two sources providing the average expenditure of a Dutch household for two different periods.

For the 1980-1996 period we used the 'Household Expenditure Surveys' as our source for the expenditure data. The Household Expenditure Surveys, compiled annually from 1980 to 1996, are based on annual surveys among a representative sample, and vary from about 1000 to 3000 Dutch households. The published time-series of the expenditure surveys give the average annual total consumption of Dutch households divided into 73 consumption categories[5]. Since 1992 Statistics Netherlands has a new definition of expenditure[6]. We have recalculated the

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3 To make these conversions we used data for the average number of household members as given by Teefelen (1994) and the total number of households as given by CBS (1991) for the years 1960 to 1988 and CBS (1990-1993) and CBS (1992-1997) for the years 1989 to 1996. For the 1948 to 1959 period, no data on the number of households in the Netherlands were available (CBS, 1991, so number of households had to be linearly extrapolated, using the total number of households in the Netherlands in 1947 according to CBS (1994).

4 The climate influence on the (small) consumption of fuel oil is ignored for 1948 to 1955 and 1969 (based on the old classifications) because of lack of information concerning the breakdown between fuel oil and petrol.

5 The expenditure surveys contain about 350 consumption categories, but for the full period from 1980 to 1996 only data for 73 categories were available. The expenditure data are extracted from CBS (1992-1997).

6 According to the definition of expenditure after 1992, subscription fees, examination and licence fees, donations, property taxes and sub tenancy are included in the household expenditure of the expenditure

expenditure according to the expenditure definition from before 1992. To eliminate the influence of price changes, the expenditure according to the annual surveys was converted to constant prices for 1990 by using (CBS, 1985-1997). The consumption categories from the expenditure surveys do not correspond exactly to the consumption categories of the price statistics. If two or more categories of the price statistics correspond to one category from the expenditure surveys, we calculate the price index from several subcategories, taking into account the share of each sub-category. The price index numbers from 1980 to 1985 are valid for households with employees and an income below the wage limit for the compulsory national health insurance. The price index numbers from 1986 to 1996 are valid for the entire population. We ignored this definition difference, assuming the price index numbers from 1980 to 1985 to also be valid for the entire population.

For the period from 1980 to 1996, the expenditures on natural gas and electricity are given not only in monetary units, but also in physical quantities (m^3 natural gas and kWh electricity) (Teefelen, 1994; Pelsers, 1998). We used the latter data to calculate the direct energy requirement using fixed conversion factors from Vringer and Blok (1995). More detailed information on the expenditure surveys can be found in Vringer and Blok (1995) and in Vringer et al. (1997).

For the 1948 to 1988 period we used the 'Private consumption expenditure and price index numbers for the Netherlands 1921-1939 and 1948-1988' (CBS, 1991) as our source for expenditure data. This publication is based on the Dutch National Accounts, which, in turn, are based mainly on the statistics for the retail trade sales (Buiten, 1993a). The National Accounts give the annual total consumption (in constant prices) for the Netherlands, divided into 96 consumption categories (CBS, 1991). The price index numbers from CBS (1991) are converted to comparable price index numbers of 1990 with the help of price index numbers from CBS (1985-1997).

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surveys. The household expenditure figures used in this chapter exclude the expenditure of these categories. We made no adjustments for changes in expenditure on medical care due to definition changes.

There are systematic differences between the National Accounts and the expenditure surveys (Buiten, 1993b)[7]. The classification of goods and services also differs for the period before and after 1969. To facilitate a comparison between the time-series from 1948 to 1988 and the time-series from 1980 to 1996, we excluded three categories from the 96 consumption categories in the National Account data that are also excluded from the expenditure survey (see Appendix 6A). In spite of these adjustments, the results based on the National Accounts cannot be compared, pure and simple, with the results based on the expenditure survey. The difference in the total expenditure is still about 10%.

We matched the detailed energy intensity figures from Vringer and Blok (1995) with the categories from the expenditure surveys for both data sources. For the expenditure surveys, this is just straightforward aggregation, based on the 1990 consumption breakdown. The matching for the National Accounts data is described in Appendix 6A.

4 ► Results

We will first discuss the general trends and the development in consumption, followed by total, direct and indirect household energy requirements, given per household and per capita. Finally, the changes in the energy intensity of the total consumption package will be quantified.

In this section, all household energy requirements and energy intensities and their changes exclude effects of energy efficiency improvements in the supply sectors and changes in consumer-product characteristics, i.e. at fixed 1990 energy intensities for each category.

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7 The total expenditure according to the expenditure surveys for the years 1988 and 1989 is about 16% lower than the total consumption according to the National Accounts. This 16% can be explained mainly by definition differences (Buiten, 1993b).

4.1 ► General trends

Before attempting to interpret the trends in the energy requirements and energy intensities of households, we will need to overview some general trends. Figure 6-1 shows trends in the population, number of households, total household expenditure, GNP at constant prices (Kattevilder, 1998) and the total Dutch primary energy requirement (CBS).

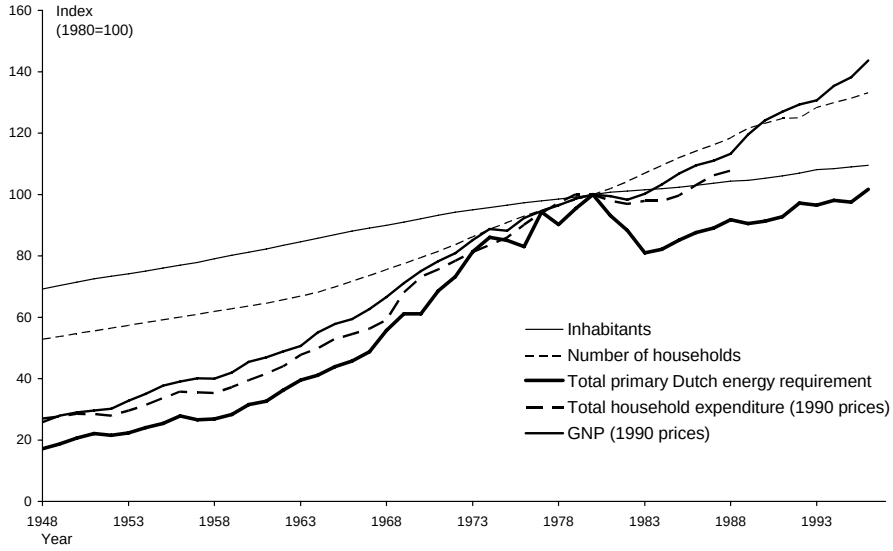

Figure 6-1 Inhabitants, total number of households, total primary Dutch energy demand (CBS)[8], total household expenditure and the GNP in constant guilders for the Netherlands.

Figure 6-1 shows that the number of households grew by a factor of 2.5 (1.9% per year) between 1948 and 1996. In this period the number of inhabitants grew by a factor of 1.6 (0.9% per year). The total household expenditure, converted to constant prices, for all Dutch households grew by about a factor of 4 between 1948 and 1988 (3.4% per year). The total Dutch primary energy requirement also grew rapidly (by a

8 Mind that the total primary Dutch energy demand (according to the conventional definition) is not comparable to the 'total Dutch household energy requirement' that will be presented later. For example, Dutch households consume products from abroad, while the Netherlands industry produces for consumers abroad.

factor of 5 between 1948 and 1988, i.e. 4% per year). The growth of the GNP (at constant prices) was about as large as the growth of the total household expenditure.

4.2 ► Development of consumption

In Figure 6-2 the development of the household expenditure per capita is shown for the period from 1948 to 1988, divided into the main consumption categories. The period after 1988 is not shown because of the incompatibility of the main consumption categories of the National Accounts with the expenditure surveys (see also the section, 'Expenditure data').

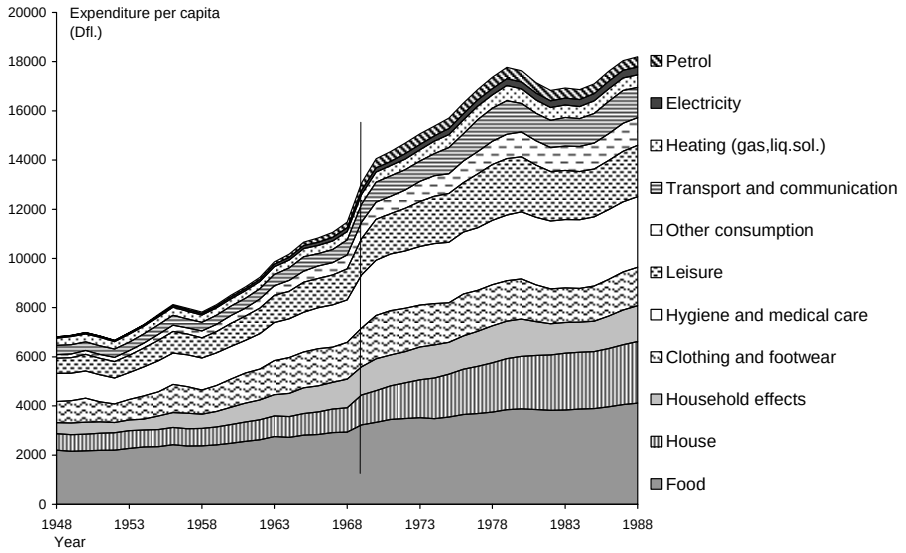

Figure 6-2 Annual expenditure (at 1990 prices) per capita from 1948 to 1988, divided into the main consumption categories. The vertical line marks the start of the new category classification introduced by CBS.

Expenditure per capita at constant prices more than doubled in the period from 1948 to 1988. Expenditure on the direct energy consumption of households (petrol, heating and electricity) varied between 5% and 8% of the total expenditure. Between 1948 and 1988 the average growth rate of household expenditure per capita was 2.4% per year. The growth rate before 1973 (3.1% per year) was more than twice the

growth rate from 1973 to 1988 (1.4% per year). Between 1955 and 1973 ‘petrol’ showed the largest growth rate (about 15% per year). The most rapid ‘growers’ besides ‘petrol’ (about 7% per year) in the whole 1948 to 1988 period were ‘electricity’ (about 5% per year) and the ‘house’ (about 3% per year). The slowest ‘growers’ were ‘heating’, ‘food’ and ‘clothing and footwear’ (about 1.5% per year).

4.3 ► Total household energy requirement

Here, we will focus on the total household energy requirement per household and per capita. Figures 6-3 and 6-4 show the total average household energy requirement per capita and per Dutch household for the 1948 to 1996 period. The household energy requirement levels for the two expenditure data sources differ by about 10%. The annual household energy requirements from 1980 to 1988 are given for both expenditure sources to check the compatibility of the results based on the expenditure surveys and the National Accounts. The 10% difference in the energy requirement level is about the same for all the years between 1980 and 1988. The definition and classification changes made by Statistics Netherlands in both

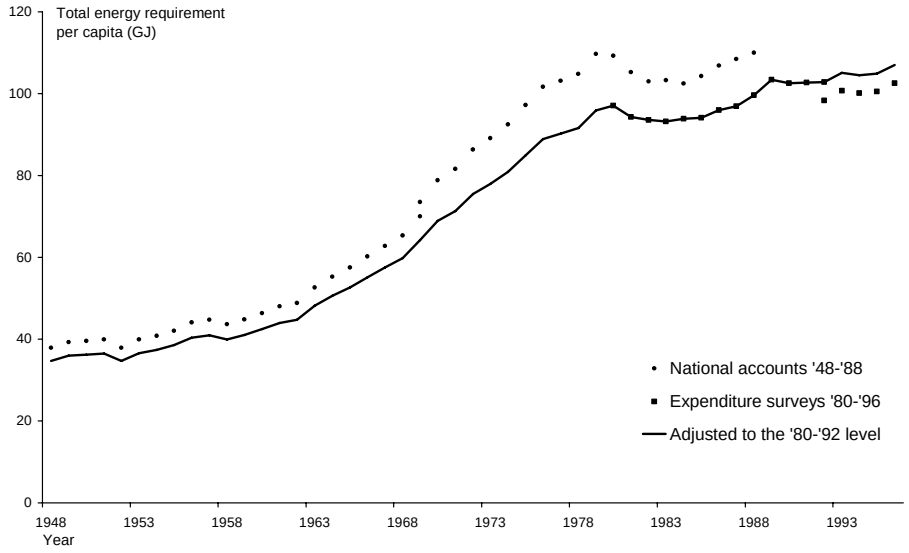

Figure 6-3 The total energy requirement per capita for the period from 1948 to 1996, calculated with fixed energy intensities for 1990.

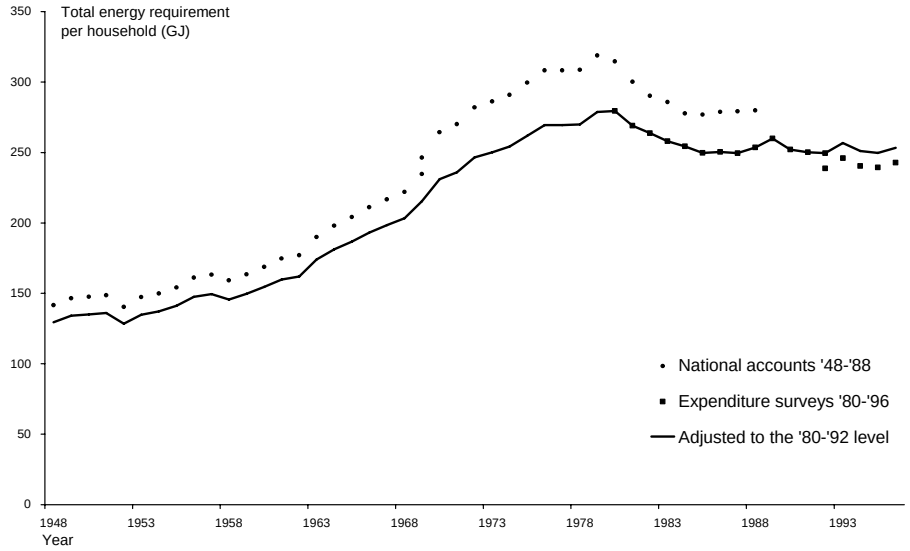

Figure 6-4 The total energy requirement per household for the period between 1948 to 1996, calculated with fixed energy intensities of 1990.

expenditure sources (one in 1969 and one in 1992) also led to differences in the energy requirement level.

We fitted a line in Figures 6-3 and 6-4 for the total time-series from 1948 to 1996 at the 1990 level. Two values of the energy requirement, based on different sources of definitions, could be calculated for three different years (1969, 1980 and 1992). The figures for the 1948 to 1979 period, and the period between 1993 and 1996, are multiplied by such a factor so that a continuous time-series is obtained. We assume the fitted line to be the best approach to describing the effect that changes in the household consumption pattern have on the total household energy requirements in relative terms. Between 1948 and 1996, changes in the household consumption patterns led to an average growth of 3.4% per year in the total energy requirement of Dutch households. This is 1% more than the increase in the energy requirement per capita (on average 2.4% per year) due to the rise in the number of inhabitants.

The total energy requirement per household grew between 1948 and 1979, declined from 1979 to 1985 and stabilised after 1985. The 1% difference in the development

of the total energy requirement per household (on average + 1.4% per year) and percapita is due to the decrease in the number of members per household from 3.7 persons per household in 1948 to 2.3 in 1996.

4.4 ► Direct energy requirement

Figure 6-5 shows the cumulative direct household energy requirement per capita, divided into several fuel types for the 1948 and 1988 period. In 1988 the direct household energy requirement per capita was 3.7 times higher than in 1948, a growth of 3.1% per year. Between 1948 and 1963 the direct household energy requirement per capita was quite stable, but grew rapidly between 1963 and 1976 (about 8% per year). Between 1980 and 1985 the direct energy requirement per capita decreased and after 1985 it increased slightly again.

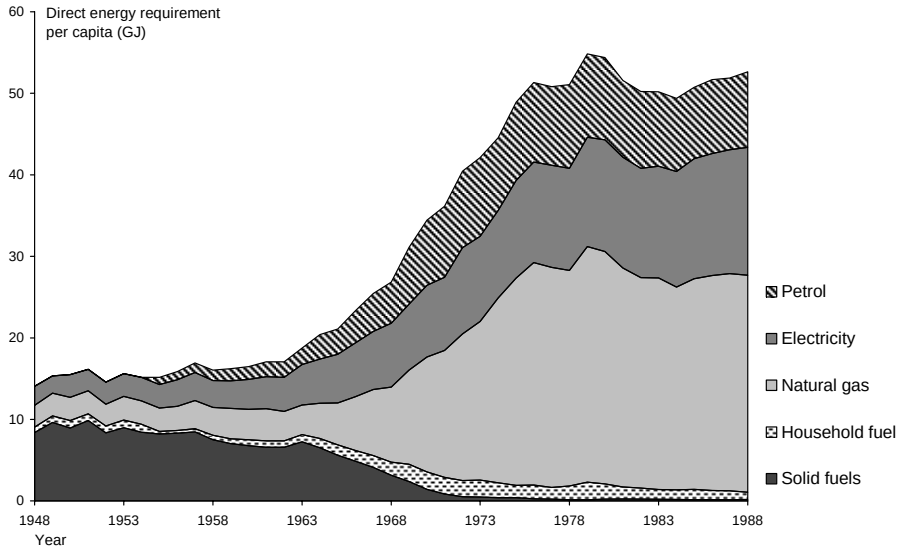

Figure 6-5 Direct energy requirement (in terms of primary energy) by households per capita for the 1948 to 1988 period.

Coal, the most important household fuel in 1948, almost ceased in use in 1973, whereas the use of natural gas grew rapidly from 1966 to 1976. After 1976 the use

of natural gas stabilised. The use of petrol grew rapidly from 1964 to 1972 and stabilised after 1972.

Of all the important energy carriers, electricity showed the fastest growth in use by households between 1980 and 1988. Vringer et al. (1997) found these trends to continue for the 1990 to 1995 period: the demand per capita for natural gas and petrol stabilised, while the demand per capita for electricity grew. The driving forces related to growth in the direct energy requirement for both heating the house and electricity consumption will be further examined.

The doubling of the energy requirement per capita for heating seen between 1948 and 1995 represents the net effect of a higher living standard (heating more rooms, a higher average temperature indoors and fewer persons per house) and efficiency improvements (better insulation and more efficient heating equipment). This increase in consumption of fuel for space heat per capita is explained by the following four factors:

- the surface area of the average Dutch house did not change significantly between 1959 and 1995 (Wolbers, 1996).
- the number of household members fell from 3.7 to 2.3, amounting to a rise in available surface area per person of a factor of 1.6 in this period.
- the energy requirement per square metre was halved between 1950 and 1995 due to energy efficiency improvements realised in this period (Nijland and van Delft, 1999).
- the fraction of the heated space in the house increased.

Between 1980 and 1996 the household electricity consumption per capita rose by about 20% (Weegink, 1997). The higher electricity consumption per capita is the net result of a higher penetration and energy efficiency improvements in electrical equipment. Without the energy efficiency improvements realised between 1980 and 1996, the electricity consumption in 1996 per capita would have been about 50% higher (about 7 to 8 GJ) due to a higher penetration of electrical equipment (Boonekamp and Jeeninga, 1999).

4.5 ► Indirect energy requirement

In 1990 about 54% of the total energy requirement of households is indirect (Vringer and Blok, 1995). Figure 6-6 relates to the period, 1948 to 1988, and shows the cumulative direct household energy requirement per capita divided into several consumption categories[9].

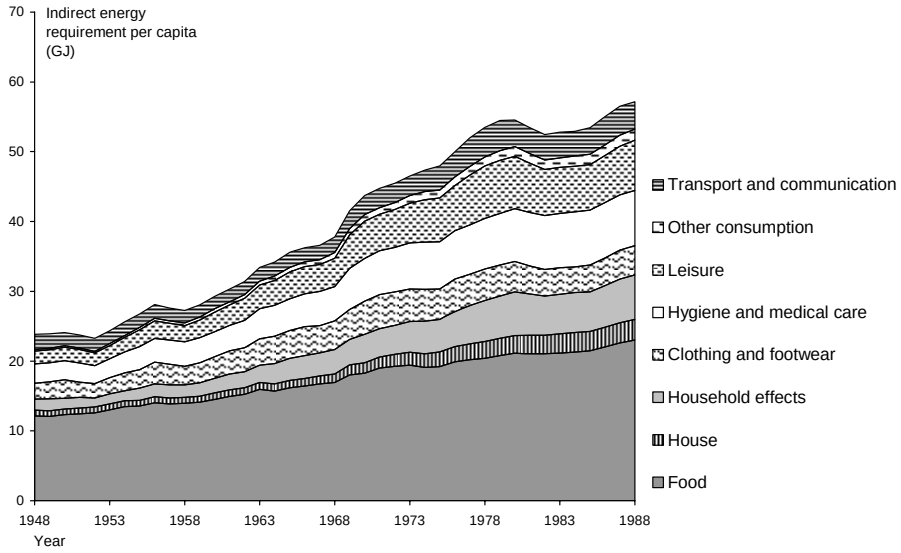

Figure 6-6 Indirect energy requirement per capita divided into main consumption categories, calculated with fixed energy intensities for 1990.

In 1988 the indirect energy requirement per capita was 2.4 times higher than in 1948, a growth of 2.2% per year. The energy requirement grew for all the consumption categories. The energy requirement for food is the largest of all the indirect consumption categories. In 1948 about half the indirect energy requirement was needed for food. Although this share had shrunk by 1988, it was still 40% of the indirect energy requirement. Growth in this category and other categories like 'clothes' and 'transport and communication' was about 1.3 to 1.6% per year. The

9 The period after 1988 is not shown because of the incompatibility of the main consumption categories of the National Accounts and the expenditure surveys (see also the section, 'Expenditure data').

energy requirement for the consumption categories, 'leisure', 'house' and 'household effects' grew by about 3.2% per year.

4.6 ► Energy intensity

Up to now we have reported on the development of the direct and indirect energy requirement in absolute terms. We will now discuss the energy intensity of household consumption, i.e. the energy requirement relative to household expenditure:

$$\varepsilon_{total} = \frac{\hat{E}_{total}}{S_{total}} \qquad \varepsilon_{indirect} = \frac{\hat{E}_{indirect}}{S_{indirect}}$$

In which:

ε_{total} = energy intensity of the total consumption
$\hat{E}_{total}$ = total household energy requirement at fixed energy intensities
S_{total} = total expenditure
$\varepsilon_{indirect}$ = energy intensity, excluding direct energy requirement.
$\hat{E}_{indirect}$ = indirect household energy requirement at fixed energy intensities
$S_{indirect}$ = expenditure, excluding expenditure on direct energy requirement

Figure 6-7 shows the development of the total and indirect energy intensity of household expenditure for the 1948 to 1996 period. In the 1948 to 1996 period the total energy intensity of households fluctuated, but did increase from 5.6 to 6.3 MJ/Dfl. (about 0.25% per year on average). If we exclude the earlier discussed energy efficiency improvements for heating the house and for electrical equipment, the total energy intensity in 1996 would have been at least 25% (about 1.7 MJ/Dfl.) higher.

The changes in the total energy intensity can be explained mainly by changes in the ratio between direct and indirect energy. The energy intensity of energy carriers is typically a factor of 12 higher than the other consumption categories. Hence,

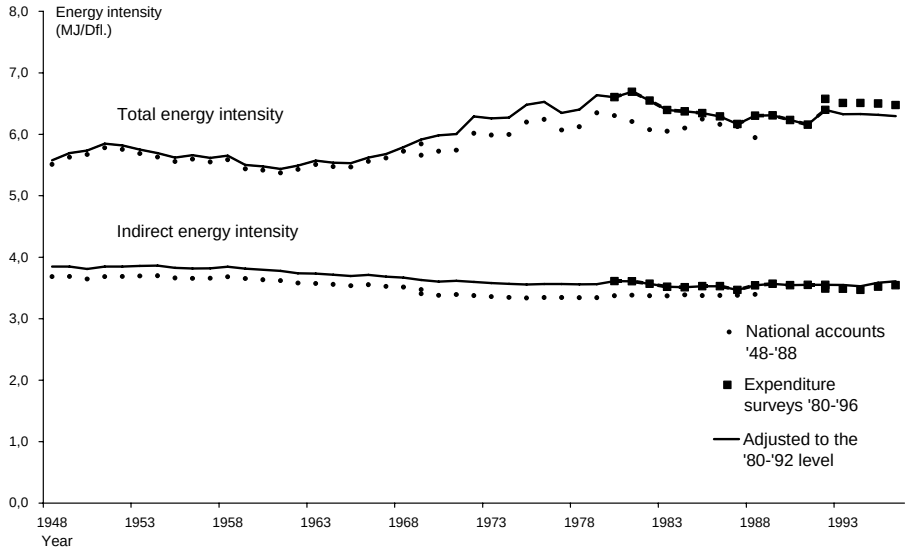

Figure 6-7 Total and indirect energy intensity for the time-series from 1948 to 1996 calculated with fixed energy intensities for the individual consumption categories. The results for both expenditure surveys are given, as well as those adjusted for the level of the 1980 to 1992 period (continuous line).

changes in the ratio have a strong effect on the total energy intensity. The share of the direct energy requirement grew from 1962 to 1975 and shrunk slightly between 1975 and 1991, see Figure 6-8. This development is fairly similar to the development in total energy intensity.

The indirect energy intensity was quite stable from 1948-1996, except for a slight decline in the indirect energy intensity. If the annual energy intensities for the different data sources are adjusted to the indirect energy intensity level for the 1980 to 1992 period, we find a decline of only 0.14% per year. The relative decrease in expenditure on food (which is fairly energy intensive) is the main cause of this reduction. Further examination shows that within the main consumption categories (food, clothing, etc.) themselves, the energy intensities hardly change. These changes play a minor role in the total change in energy intensity.

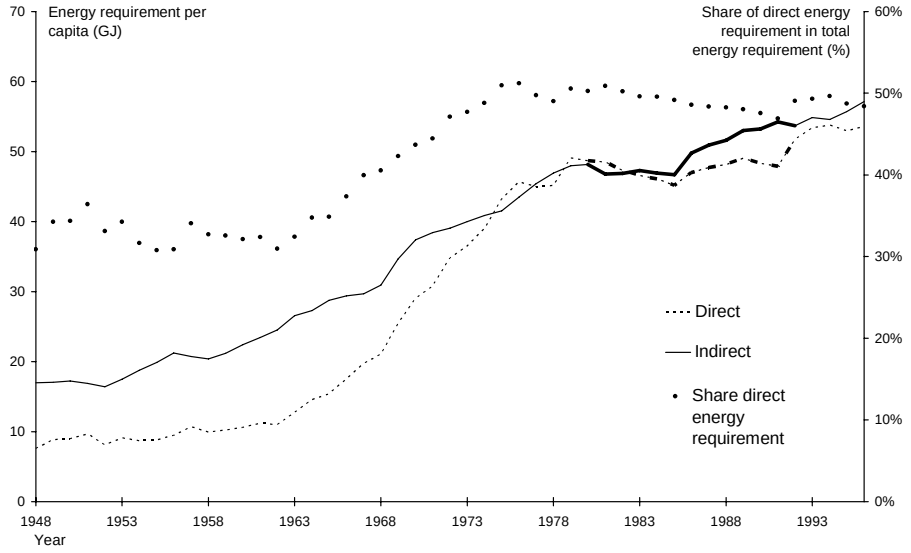

Figure 6-8 Direct and indirect household energy requirement per capita from 1948 to 1996, calculated with fixed energy intensities for 1990. The energy requirement for the periods, 1948 to 1980 and 1992 to 1996, are fitted at the 1980 to 1992 level (indicated in bold), based on the expenditure surveys. The share of direct energy requirement in the total energy requirement is also shown.

5 ► Discussion

Several comments should be made with respect to the results, namely that:

(1) the energy requirement resulting from the consumption of several public services and the infrastructure is not included.

(2) the composition of the consumption categories is assumed to be constant.

(3) the results of the time-series from 1948 to 1988 have to be interpreted with extra care.

These aspects will be dealt with below. Furthermore, we will also examine how the energy requirement would have developed if we had refrained from using constant 1990 energy intensities.

(ad 1) The demand on public services (i.e. government expenditure) is excluded from this survey. The share of this collective consumption expenditure varied from

15% of the national final expenditure in 1950 to 20% in 1990 (CBS, 1994). For 1990 we estimated the energy intensity of collective consumption at about half of the energy intensity of household consumption (Vringer and Blok, 1995). Taking this into account we estimated the indirect energy intensity of household consumption and government consumption to have declined by 0.2% per year (instead of 0.14% for households only).

(ad 2) The composition of products in the consumption categories is assumed to be constant, which is a consequence of the assumption that there is a constant energy intensity per category for the whole time-series. Shifts between sorts of products within consumption categories (like a shift from pork to beef in the category 'meat') could not be taken into account because of a lack of data. However, the most important consumption categories are fairly homogeneous (see Appendix 6A), which limits the magnitude of possible errors.

(ad 3) The results of the time-series from 1948 to 1988 which so far are based on data from CBS (1991) have to be interpreted with extra care. The energy intensities used here are based on the expenditure survey for 1990 (Vringer and Blok, 1990). The consumption categories of the National Accounts differ systematically (on average by 16%) from the consumption categories of the expenditure surveys. However, the *relative* changes in the total energy requirement for the overlapping years for both time-series are comparable. This fortifies the assumptions made by coupling the energy intensities to the expenditure according to the National Accounts.

Finally, we will examine the effect of our assumption that the energy intensity of the various consumption categories was kept constant at the 1990 level during the period studied. This means that the energy requirements presented here do not reflect the actual energy requirement, but do reflect what the energy requirement would have been if the energy intensities of the industry, distribution and transport sectors had not changed through the years. In other words, the time-series reflect only those changes in the energy requirement that can be assigned to changes in the consumption patterns of the Dutch households. To obtain an idea of the actual energy requirement of households, we estimated the effect of energy efficiency changes in the supply sectors. For the 1990 to 1995 period, Vringer et al. (1997) calculated a 2% reduction in the household energy requirement due to energy

efficiency changes in the supply sectors. For the 1973 to 1988 period, Meyer and Schipper (1992) observed a decline in the average energy intensity for OECD countries. This decline led to a primary energy requirement reduction of around 20% (about 1.2% per year). If we assume that this is also valid for the supply sectors for Dutch households, the actual energy requirement in 1973 would be about 10% higher than if it had been calculated without the influence of energy intensity decrease of the supply sectors. If the energy intensity decrease between 1973 and 1988 is extrapolated to the 1948 to 1973 period, the actual energy requirement in 1948 would be more than 40% higher than the energy requirement calculated at fixed 1990 energy intensities. Figure 6-9 shows the energy requirement per capita for the 1948 to 1996 period, excluding and including the above estimated energy intensity changes of the supply sectors.

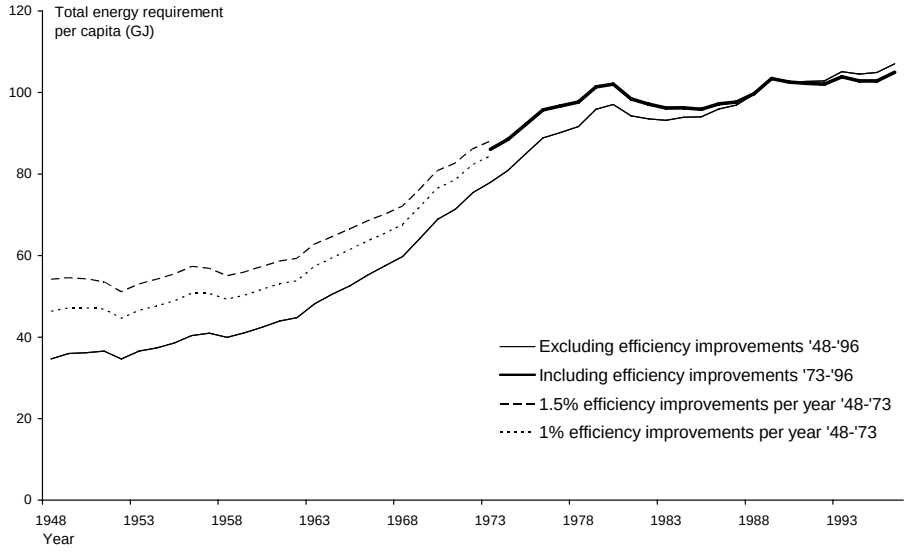

Figure 6-9 Estimate of the total energy requirement per capita for the range in time from 1948 to 1996, excluding energy efficiency improvements in the supply sectors and including an estimation of the energy efficiency improvement in the supply sectors. The extrapolated period (dotted lines) is given for a percentual decrease in the energy intensity of 1% and 1.5%.

6 ► Conclusions

As a result of a rise in consumption, the total household energy requirement per capita grew between 1948 and 1996 by about 2.4% per year (calculated with fixed energy intensities, ignoring efficiency changes in the supply sectors). In this period changes in household consumption patterns led to a growth in the total energy intensity, with some fluctuations, from 5.6 to 6.3 MJ/Dfl. (about 0.25% per year). It is the share of the direct energy requirement in the total household energy requirement that determines the fluctuations in the total household energy intensity. Without energy efficiency improvements for heating and electrical equipment, the growth in the total energy intensity would have been substantially higher.

Between 1948 and 1996 the indirect energy intensity remained almost unchanged, but there was a small decline from 3.8 to 3.6 MJ/Dfl. (about 0.14% per year). The main reason for this reduction is the decrease in the share of the energy requirement for food. We may have overlooked some changes due to insufficient detail in our breakdown (75 to 100 consumption categories), although there is no indication of this. The finding that increasing income does not lead to a lower energy intensity caused by the composition of the consumption pattern is consistent with earlier findings: an analysis for one specific year (1990) showed that the indirect energy intensity of higher income groups was not lower than for lower income groups. But, there was a decline found in the total energy intensity, due mainly to the fact that higher income groups use proportionally less natural gas than lower income groups. Again it should be stressed that we have considered only changes in the household consumption package; we ignored energy efficiency effects in the production sectors.

No substantial trend to a lower energy intensity was found, indicating that dematerialisation of the Dutch consumption pattern did not occur. If we consider only indirect energy consumption, we find a very slight reduction in energy intensity. In conclusion, the consumption pattern of households in the Netherlands does not show a substantial trend towards a lower energy intensity.

If governments are to pursue sustainable development they will have to take into account that autonomous dematerialisation of the consumption pattern is unlikely to

occur. Strong policy may very well be necessary to achieve dematerialisation by means of changes in household consumption patterns.

► Acknowledgements

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Appendix 6A ► Matching consumption categories and energy intensities

Table 6A-1 shows the consumption categories of the National Accounts (CBS, 1991) matched with the consumption categories and energy intensities according to (Vringer and Blok, 1995). A few consumption categories have been added: e.g. banking services', 'insurance services' and 'services not mentioned before'. The energy intensities of the consumption categories added are appraised at 1.0 MJ/Dfl., comparable to other service categories.

We constructed main consumption categories from the 96 consumption categories from the National Accounts (CBS, 1991), taking into account as far as possible the classification of the main consumption categories of the Household Expenditure Surveys. The following consumption categories may be placed under more than one main consumption category, e.g.

- Household effects (a main consumption category) include part of consumption category no. 3411, 'Other articles for household use', which in turn consist of the sub-category no. 3403, 'household utensils', and no. 3408, 'washing machines and refrigerators', as well as part of the sub-category no. 3411, 'other articles for household use'.
- The main consumption category, 'Leisure and education', includes part of the consumption category no. 3411, 'other articles for household use'. This then consists of the sub-consumption categories, no. 3409, 'radio/TV', no. 3410, 'records and cassettes' and half the sub-consumption category, no.3411, 'other articles for household use'.
- Up to 1955 the consumption category, 'Heating', included category no: 4102 'Liquid fuel', which consists of fuel oil and petrol. After 1955 only fuel oil is included in this main consumption category. From the year 1955 on, the expenditure on petrol was known separately and assigned to the main consumption category 'Petrol'. Before 1955 the energy requirement of petrol is included in the main consumption category 'Heating'.

Table 6A-1 Energy intensities for the consumption categories from the National Accounts, the matched energy intensities and the matched sector number.

Category according to the National Accounts		**Category according to the expenditure surveys**		**Energy intensity**
No.	Name	No.	Name	MJ/Dfl.
	Food			
1101	Rice, groats and oatmeal	110720	Rice	5.7
1102	Noodles/macaroni	110750	Other flour and dry goods	6.9
1103	Tea	113600	Tea	4.3
1104	Coffee	113500	Coffee	3.4
1105	Cocoa	113700	Cocoa	2.6
1106	Chocolate spread	113300	Chocolate paste/butter for bread	4.8
1107	Sugar	113000	Sugar	11.2
1108	Fruit preserves	11250	Preserved Fruit	6.4
1109	Margarine	115000	Margarine	11.0
1110	Edible fat	115110	Fats for frying and deep frying	15.3
1111	Edible oils	115120	Salad oil	26.0
1113	Other groceries	1196	Other food products and beverages	5.4
1201	Standard milk	118000	Milk	6.3
1202	Butter	118500	Butter	6.7
1203	Cheese	118600	Cheese	5.8
1204	Cream and condensed milk	118300	Evaporated milk and Cream	5.4
1205	Skimmed-/butter milk	118400	Other milk products	5.8
1206	Yoghurt	118100	Yoghurt	5.3
1207	Chocolate milk	118400	Other milk products	5.8
1208	Special milk products	118400	Other milk products	5.8
1209	Eggs	118700	Eggs	11.1
1300	Bread	110000	Wholemeal bread	4.0
1401	Potatoes	1110	Potatoes	4.4
1402	Vegetables	1111	Vegetables	8.8
1403	Fruit	1120	Fruit	5.2
1405	Vegetable preserves	11160	Preserved and dried vegetables	9.9
1501	Beef and veal	116000	Beef and veal, fresh	5.7
1502	Pork	116100	Pork, fresh	5.7
1503	Other meat	116520	Other meat products	7.3
1504	Meat preserves/meat prod.	116400	Meat and meat products, frozen	9.3
1505	Poultry (incl. ducks)	117020	Poultry	6.0
1601	Fresh fish	117100	Fish, fresh	5.8
1602	Fish preserves	117340	Preserved fish	12.0
2101	Sugar and chocolate prod.	113130	Sugar products on bread	6.6
2102	Gingerbread	110300	Bread with raisins	4.2
2103	Dutch rusks	110200	Rusks and other sorts of bread	3.9

Table 6A-1 Energy intensities for the consumption categories from the National Accounts, the matched energy intensities and the matched sector number. (Cont.)

Category according to the National Accounts		**Category according to the expenditure surveys**		**Energy intensity**
No.	Name	No.	Name	MJ/Dfl.
2104	Biscuits/cakes/pastry	1105	Cake, biscuits and pastry	3.8
2105	Pastry products	110730	Pastry	4.7
2301	Beer	114110	Beer	3.1
2302	Other alcoholic beverages	11410	Alcoholic beverages	3.0
2303	Non-alcoholic beverages	11400	Non-alcoholic beverages	7.3
2400	Ice cream	119500	Ice cream	4.1
4400	Expenditure in restaurants	1193	Outdoor consumption	4.1
	House			
4300	Gross rent	2200	Rent and rental value	1.2
	Household effects			
3401	Heating equipment	2267	Heating appliances (except central heating)	2.4
3404	Earthenware for hh. use	226300	Pottery and glassware	3.0
3405	Glassware	226300	Pottery and glassware	3.0
3406	Wood products	224000	Dining and livingroom furniture	3.2
3407	Furniture	2240	Furniture	3.4
3411	Other articles for hh. use	2275	Other household appliances and tools	4.0
4801	Flowers and plants	222200	Indoor plants and flowers	15.6
4807	Maintenance services	227800	Repair and maintenance of household appl.	1.1
4815	Service of metal-using craft	221140	Service for maintenance of central heating	1.0
	Clothing and Footwear			
3101	Men's outer garments	3300	Men's clothing	3.0
3102	Ladies outer garments	3306	Women's clothing	2.4
3103	Underwear and nightwear	330500	Night-gowns and underwear	2.8
3104	Rainwear	330000	Men's coats	3.9
3105	Stockings and socks	330750	Ladies tights	2.1
3106	Fashion articles	3340	Other clothing and requisites	3.0
3107	Yarns	3340	Other clothing and requisites	3.0
3108	Woven fabrics	3340	Other clothing and requisites	3.0
3109	Soft furnishings	3340	Other clothing and requisites	3.0
3112	Other textile products	3340	Other clothing and requisites	3.0
3200	Footwear	335	Footwear and finery	1.8
3300	Leather articles	338200	Leather goods etc.	2.8
4813	Shoe repairs	338000	Shoe repairs	2.3

Table 6A-1 Energy intensities for the consumption categories from the National Accounts, the matched energy intensities and the matched sector number. (Cont.)

Category according to the National Accounts		**Category according to the expenditure surveys**		**Energy intensity**
No.	Name	No.	Name	MJ/Dfl.
	Hygiene and Medical Care			
4203	Water	441000	Water	2.4
4803	Cosmetic products	4440	Cosmetics and perfumery	2.5
4804	Detergents	441210	Detergents	6.8
4808	Service of cleaning firms	440230	Window cleaning service etc.	0.1
4809	Household services	4400	Domestic services	0.6
4810	Service hairdr./beauty shops	443000	Hairdresser	1.4
4811	Service of dyers/laundries	440100	Laundry, dry cleaning, dye works	3.0
4700	Medical care	446	Medical care	3.0
4805	Medical/pharm. products	44600	Medicines, wound-dressings and prostheses	1.7
	Leisure and Education			
4500	Entertainment services	5530	Music, singing and theatre	1.9
4802	Paper products	550200	Study books and educational appliances	2.6
4806	Goods/serv. by publishers	550500	Newspaper and weekly papers	5.7
4812	Service of swimming est.	5510	Sports and games	2.6
4814	Service of photographers	554420	Film and photo accessories	1.7
3700	Other durables	226	Household appliances and tools	3.5
3411	Other articles for hh. use	2275	Other household appliances and tools	4.0
2201	Cigars/cigarillos	556000	Cigars	1.2
2202	Cigarettes	556100	Cigarettes	0.9
2203	Cut tobacco	556200	Other tobacco articles	1.3
	Transport			
3500	Bicycles and motorcycles	5574	Mopeds, motor-cycles etc.	2.2
3600	Automobiles	5576	Cars	2.4
4601	Transport services	558430	Cargo services	6.8
4602	Communication	5582	Other transport & communication services	1.9
	Heating			
4101	Solid fuel	2292	Solid fuels	38.5
4102	Liquid fuel	558100	Petrol and motor oils	22.4
4202	Gas	229010	Natural gas	59.1
	Electricity			
4201	Electricity	229110	Electricity	49.4

Table 6A-1 Energy intensities for the consumption categories from the National Accounts, the matched energy intensities and the matched sector number. (Cont.)

Category according to the National Accounts		**Category according to the expenditure surveys**		**Energy intensity**
No.	Name	No.	Name	MJ/Dfl.
	Petrol			
4102	Liquid fuel	558100	Petrol and motor oils	22.4
	Other consumption			
4816	Banking services			1.0
4817	Insurance services			1.0
4818	Services not mentioned before			1.0
4822	Goods not mentioned before			3.5
	Excluded			
4819	Social services			
4820	Contrib. inst. of worship			
4821	Government services			