A reduction in the indirect energy requirement of households

Kees Vringer, José Potting, Kornelis Blok, Department of Science, Technology and Society, Utrecht University
Rixt Kok, Centre for Energy and Environmental Studies, State University of Groningen

1. SYNOPSIS

In this paper the effect of measures to reduce the indirect energy requirement of households is evaluated.

2. ABSTRACT

One way of reducing CO_2 emissions is to reduce household energy requirements by changing household consumption patterns. In analysing the effect of such changes, one has to take both direct and indirect energy requirements into account. The total average energy requirement per household in the Netherlands in 1990 was estimated to be 240 GJ, of which 46% was direct (natural gas, electricity, petrol) and 54% was indirect (indirect energy is defined as the energy embodied in consumer goods and services). A strong relation was found between household expenditure and total (direct plus indirect) energy requirement.
The real net income in the western world is expected to rise gradually over the coming decades. This rise is expected to increase the energy consumption of households. This is why it is interesting to examine ways of reducing the indirect energy requirement of households without substantially affecting the development of living standards.
Reduction measures can be divided into three groups:
A Choosing a product variant which has a lower energy requirement. The variant costs about the same and has roughly the same function as the average products.
B Choosing a variant which has more of less the same (physical) function but which costs much more and provides greater pleasure and/or comfort.
C Shifting consumption patterns whereby high energy intensive functions are replaced by low energy intensive functions.
An inventory of measures is drawn up for each of the three groups. The effects of these measures are evaluated using a method that is a hybrid of process energy analysis and input-output analysis. Each measure may lead to changes in indirect energy requirement and/or household expenditure.

If all the proposed measures were to be realized, the total indirect energy requirement of an average Dutch household would be reduced by 9% (12 GJ). The indirect energy intensity of household expenditure would decrease from 7,8 MJ/ECU to 5,6 MJ/ECU (-29%). Measures in group A could reduce the indirect energy intensity of household expenditure to 6,9 MJ/ECU (-12%). Measures in group B could reduce the indirect energy intensity by 16% and measures in group C could reduce the indirect energy intensity by 4%. Since these measures could lead to a substantional decrease in the energy requirement of households, further research seems justified. In such research emphasis should be on studying the extent to which the shifts in consumption patterns are feasible and socially acceptable.

3. INTRODUCTION

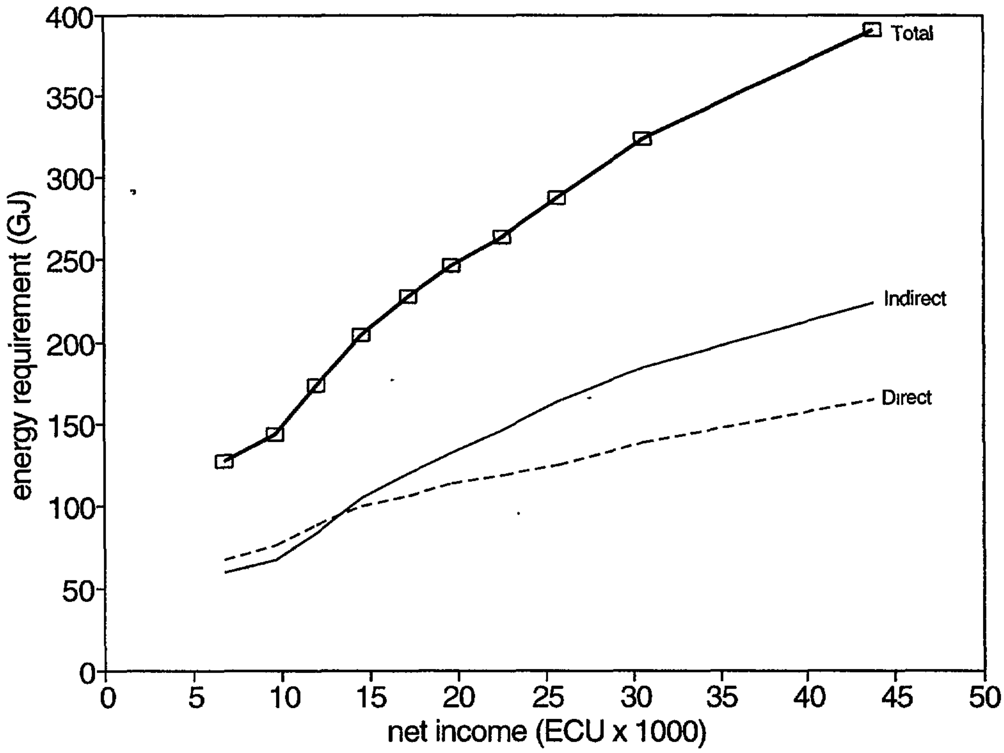
The use of fossil energy is one of the main causes of CO_2 emissions. One way of reducing CO_2 emissions is to reduce household energy requirements by changing household consumption patterns. A household not only uses direct energy in the form of natural gas, electricity and petrol, but it also uses indirect energy embodied in consumer goods (like food and furniture) and services.
In this paper the direct energy requirement of households is calculated as follows: the direct consumption of secondary energy carriers such as petrol, electricity and natural gas is multiplied by the ERE (energy requirement for energy) of the respective energy carrier. Multiplication is required because this product is about the same as the primary energy requirement.
The indirect energy requirement concerns the total primary energy requirement embodied in products and services, including waste disposal. The (indirect) energy intensity is defined as the (indirect) energy requirement of a product or service, divided by the total consumer price of the product and is expressed in MJ/ECU.

For simplification we omit from the indirect energy requirement of households the energy requirement of public services and the energy requirement for goods which are paid for indirectly by means of taxes. The total energy requirement of households is the sum of the direct energy requirement and the indirect energy requirement.

Vringer and Blok (1993a) estimated the total average energy requirement per household in the Netherlands in 1990 to be 240 GJ, 54% of which was indirect. Table 1 shows the average energy requirement of Dutch households with respect to the main consumption categories (Vringer and Blok 1993a). Both direct and indirect energy requirements increase with income, but the increase in the indirect energy requirement is stronger, see Figure 1.

Table 1. *The average energy requirement of Dutch households (Vringer and Blok 1993a)*

	Energy requirement (GJ)	(% of total)	Energy intensity (MJ/ECU)
Total	***240***	***100***	***14,2***
Indirect energy requirement	*130*	*54*	*7,9*
Food	41	17	12,6
House	9	4	3,2
Household effects	19	8	12,4
Clothing & footwear	8	3	6,1
Medical care	12	5	7,7
Hygiene	5	2	9,2
Education & recreation	24	10	8,8
Transport & communication	11	5	6,3
Direct energy requirement	*110*	*46*	*101*
Electricity	28	12	105
Heating	60	25	130
Petrol	22	9	50



The real net income in the western world is expected to rise gradually over the coming decades. This rise in income is expected to increase the indirect household energy requirement (Vringer and Blok 1993a); therefore it is interesting to work out the possible ways of reducing the growth in the household energy requirement without affecting the total amount of income or expenditure. In this paper we make a tentative estimate of possible reductions in the indirect energy requirement. The aim of this paper is to obtain an estimate of the order of magnitude of the total reduction attainable, and to get an overview of the options that contribute to this total. The direct energy requirement (natural gas, electricity and petrol) is not considered in this paper.
We begin by describing an approach. Next we mention some of the limitations of this study and we estimate the results of various energy reducing measures. This is followed by the discussion and conclusions.
All monetary quantities are expressed in ECU (1 ECU = 2,25 Dfl).

4. APPROACH

The basis of the calculations made in this paper is the consumption of an average Dutch household in 1990, divided into about 350 consumption categories (CBS 1992a). For each consumption category Kok et al. (1993), de Paauw and Perrels (1993), Vringer and Blok (1993b) and Vringer et al. (1993b) give an energy intensity. They used a hybrid energy analysis method. This method allows the cumulative energy requirement of a consumption item to be calculated relatively easily in a fairly accurate way. This is achieved by combining the best elements of two existing methods for determining the cumulative energy requirement of goods and services: process analysis and input-output analysis (Engelenburg et al. 1994).
Vringer and Blok (1993a) calculated the energy requirement of an average Dutch household in 1990 by multiplying the energy intensities by the expenditure.
The energy requirement calculations, including the reduction options, are based on the reports and the method mentioned here, unless indicated otherwise.

For this analysis, we selected the consumption categories (excluding the consumption categories which require direct energy) that have a relatively high (indirect) energy requirement or energy intensity. The reduction measures can be divided into three groups. These are:
A Choosing a product variant which has a lower energy requirement. The variant costs about the same and has roughly the same function as the average products.
B Choosing a variant which has more of less the same (physical) function but which costs much more and provides greater pleasure and/or comfort.
C Shifting consumption patterns whereby high energy intensive functions are replaced by low energy intensive functions.
Per group we examine the possible energy requirement reduction per selected consumption category by estimating the possible changes within a consumption category; our estimates are often based on a "common sense" approach. Sometimes this approach can be supported by literature concerning consumer behaviour.
The consequences of taking the proposed measures are calculated.

5. LIMITATIONS

The calculations in this paper are based mainly on figures and energy intensities from (Vringer and Blok (1993a), (Kok et al. 1993), (de Paauw and Perrels 1993), (Vringer and Blok 1993b) and (Vringer et al. 1993b). Additional assumptions had to be made because of a lack of data. Before giving the results, we present a qualitative overview of the reliability of the assumptions made in this study.

The energy intensities given in the studies mentioned above are based on average products and average prices. Several consumption categories contain various products with different energy intensities (e.g. an expensive hand-made chair and a cheap chair). The first one probably has a much lower energy intensity than the latter. In reality there is not a one-to-one relation between the energy requirement and price. This uncertainty however will have no effect on most of the results presented in this paper since it will be averaged out over larger groups. However, there is one notable exception. It is conceivable that households with a higher income (or a higher expenditure level) systematically buy products that cost more per physical unit. If so, Figure 2 does not show the correct relation between energy requirement and household expenditure and an autonomous shift in the energy intensity can be expected if the average net household income increases.

In some cases there is uncertainty about the energy requirement of the alternative products or services, e.g. of cotton and woollen clothes and the services of the plumber.

The most important uncertainty is whether the proposed substitutions, reductions and shifts can be implemented. We do not know how much the life of products will be lengthened or whether it will be possible to shift to products with an individualised design and what the effects of this will be. It is also uncertain whether food patterns can be shifted and what the effects will be of receiving (more) domestic services and shifting to consumption categories with a low energy intensity.

With these limitations in mind we present the following results.

6. RESULTS T

The three groups of energy requirement reducing measures and their energy reduction potential will be discussed in this section. The assumptions, the estimation of the possible reduction of the energy requirement and the financial consequences will be dealt with per product or product group in each sub-section. For an average Dutch household in 1990 the indirect energy requirement amounted to 130 GJ, whereas the annual expenditure (excluding the expenditure on natural gas, electricity and petrol) was ECU 16.700 (Vringer and Blok 1993a).

6.1. Choosing a product variant which has a lower energy requirement.

The function of the product remains more or less the same. The alternative may cost slightly or slightly less. Also it may cause the consumer some inconvenience.
The results of the reduction measures in this group will be discussed in three sections: extending the lifetime of products, product and material substitution and the sharing of durable products.

Table 2 shows the consequences of extending the lifetime of products by purchasing higher quality products and increasing the amount of repairs. The repairs are assumed to be cost neutral. This means that the annual costs remain the same. The energy intensity of repairs is assumed to be 2,25 MJ/ECU (analogous with the energy intensity of repair-services according to (Vringer et al. 1993b). The following additional assumptions are made:

(a) We assume that the lifetime of 50% of the furniture can be doubled, due equally to improved quality and repairs. It is assumed that the other 50% of the furniture will be replaced at the present rate because of changing fashion.

(b) The basis of the estimate for household appliances and tools is the difference between an average washing machine with an energy requirement of 4,7 GJ (Vringer et al. 1993b) and a lifetime of 13,6 year derived from (van Dijk and Siderius 1992) and an expensive washing machine of high quality with an energy requirement of 5,5 GJ (type: Miele W723). To estimate the energy requirement of the Miele washing machine the following input data are taken: Total weight: 104 kg, 1,5 kg of which is cardboard and 0,5 kg is plastic (both need for packing), 4 kg ABS, 1,53 kg glass, 3,2 kg wood, 1,73 kg rubber (SBR) and 76,9 kg steel (Miele 1991). The price including VAT is assumed to be ECU 1022 (VEEN 1990). The energy requirement includes the transport of the washing machine (900 km by lorry) and waste disposal (including the recycling of all the steel). The lifetime is estimated to be 25 years.
Both estimates of the energy requirement are made using Wilting (1992). The ratios of energy requirement to costs for these washing machines we considered to be valid for all household appliances and tools and extension of the lifetime is assumed to be 100% if necessary repairs are carries out.

(c) The purchase of high quality shoes instead of cheap shoes will quadruple the lifetime (from 0,5 year to 2 year) of shoes (Perdijk 1993). The lifetime lengthening as a result of repairs is assumed to be 0,5 year. The energy requirement of a cheap shoe is about 30% lower than that of a quality shoe (current market-share: 10%) (Perdijk 1993). Assumed costs per pair of fashion shoes: ECU 28 (Berger 1993), quality shoes: ECU 67. Vringer et al. (1993a) mention a few more options (e.g. the lengthening of the lifetime of cars and audio/video-equipment) which have not been evaluated here because they do not seem to contribute to a reduction in the energy requirement of households.

Table 2. The consequences of extending the lifetime of products

	Energy requirement (GJ)	Expen-diture (ECU)	Extra En.req. (GJ)	Extra Exp. (ECU)	Assumptions
• furniture	2,3	296	- 0,4	0	(a)
• household appliances and tools	4,0	375	- 1,6	- 62(b)	
• shoes	0,8	214	- 0,5	- 48(c)	

Table 3 shows the consequences of the substitution of products and product groups by energy saving alternatives. The following assumptions are made:

(a) We assume that all preserved vegetables (tinned, frozen etc) (41,4 MJ/kg) are replaced by fresh vegetables (8,4 MJ/kg) (Kok et al. 1993). Substitution of preserved meat, fish and fruit turned out to have only a negligible effect on reducing the energy requirement.

(b) We assume that all vegetables grown in greenhouses are replaced by fresh vegetables in season. About 57% of Dutch vegetables and 1,8% of Dutch fruit are grown in greenhouses (PGF 1990).

(c) We assume that all imported fruit and vegetables are replaced by fruit grown locally. At present about 11% of all vegetables and 74% of all fruit are imported (CBS 1992b). Most fruit and vegetables transported by lorries come from countries in Europe; non-European fruit and vegetables are transported mainly by ship (CBS 1993). The assumed average distance over which imported vegetables and fruit are transported is 950 and 1.100 km respectively by lorry and 2.100 and 4.500 km respectively by ship. The energy requirement for transport per ton-kilometre is given by Wilting (1992).

(d) We assume a reduction in the quantity of meat or fish consumed currently (110 gr, (Kok et al. 1993)) to the recommended quantity per person per day (95 gr); a substitution of 50% of meat products used on bread and in meat-containing snacks by vegetables; one vegetarian meal a week with nuts instead of meat; a reduction in the quantity of cheese consumed currently (40 gr (Kok et al, 1993)) to the recommended quantity (15 gr) per person per day as a result of substituting 63% of the average use of cheese by vegetables.

(e) We assume a substitution of disposable bottles, cartons and tins for dairy products and soft drinks by returnable bottles, taking into account the market share of the current packaging (Jansen et al. 1990) and (Rijsdorp et al. 1989); a substitution of 50% of cartons (for e.g. rice, frozen foods) by polyethylene bags. A reduction in the energy requirement for packaging the above mentioned strongly reduced quantity of preserves is neglected.

(f) We assume that 50% of the flowers and plants bought as gifts are replaced by other kinds of low-energy intensive gifts (e.g. books or compact disks). It is assumed that 90% of the remaining 50% of flowers and plants grown in greenhouses will be flowers and plants not grown in greenhouses.

(g) A 100% substitution of polyamide floor-covering by woollen floor-covering and a 100% substitution of vinyl floor-covering by linoleum floor-covering. The assumed energy requirements are taken from (Potting and Blok 1993).

(h) We assume a shift from an average of 50% synthetic materials to 75% natural materials. The assumed present material composition is taken from (de Paauw and Perrels 1993). The energy requirement for synthetic materials is assumed to be 70 MJ/kg, for carpet wool it is assumed to be 14 MJ/kg (Potting and Blok 1993); we assume the energy requirement for cotton twice as high as that of wool. By analogy with (Potting and Blok 1993) it is assumed to achieve cloth of the same quality one requires 1,6 times more materials than of synthetic materials. The price per kg synthetic and natural material is assumed to be the same (CBS 1991a). Our estimate is based on the assumption that 25% of all clothes can be repaired.

(i) A switch from car and aircraft to train is considered. Means of transport used for foreign holidays are mainly the car (60%), coach (13%) and aircraft (19%) (CBS 1991b). The distance driven per car for holidays in the Netherlands in 1990 was 1.300 km for holidays averaged over all cars; the average fuel consumption was 8,3 litre per 100 km (CBS 1992c). Assumed number of persons in the car during holidays: 2,4 persons (average number of household members (CBS 1992a), whereas the normal occupation is 1,5 persons per car (BGC 1991). The 60% higher occupation is also assumed for aircraft and train. The direct energy requirement of the means of transport and the prices of fuels and patrol are taken from (BGC 1991) and (Wilting 1992). The cost of train travel is derived from the long-distance charges of the Dutch Railways and the cost of air travel is derived from (de Paauw and Perrels 1993).

(j) An average reduction of 50% in the transport distance is assumed, taking into account the assumptions made in the previous section.

Table 3. The consequences of the substitution (and reducing) of products and product groups by energy-saving alternatives

	Energy requirement (GJ)	Expen-diture (ECU)	Extra En.req. (GJ)	Extra Exp. (ECU)	Assumptions
• preserves	2,3	112	- 0,8	- 26	(a)
• vegetables from greenhouses	2,7	142	- 1,9	- 44	(b)
• imported vegetables and fruit			- 0,4		(c)
• animal products	12,8	810	- 4,7	290	(d)
• disposable packaging of food-products			- 0,7		(e)

• flowers and plants from greenhouses	4,4	124	- 3,2	0	f)
• synthetic floor-covering	1,2	101	- 0,4	121	(g)
• synthetic clothing	6,3	933	- 1,6	139	(h)
• holiday transport		154			
by aircraft and car			- 1,5	40	(i)
reducing holiday transport distance			- 1,0	40	(j)

Table 4 shows the consequences of sharing durable products with other households. The following assumptions are made:

(a) We assume that 50% of the households share a car, caravan and/or boat. A 30% reduction in the lifetime of the consumption products is assumed. A reduction in the use of the car, caravan and boat because of decreased availability is not taken into account.

(b) We assume that 50% of tools, newspapers and weekly papers will be shared. With regard to tools no reduction in their lifetime is taken into account.

Table 4. The consequences of sharing durable products with other households

	Energy requirement (GJ)	Expenditure (ECU)	Extra En.req. (GJ)	Extra Exp. (ECU)	Assumptions
• cars	6,1	889	- 0,9	- 222	(a)
• caravans and boats	0,5	50	- 0,2	- 25	(a)
• tools	0,3	25	- 0,2	- 8	(b)
• newspapers and weekly papers	2,1	188	- 0,5	- 47	(b)

6.2. Choosing a variant which has more of less the same (physical) function but which costs much more and provides greater pleasure and/or comfort.

The function of the product does not necessarily remain unaltered but can extend, unlike the products in the group described in section 6.1. Accordingly, the costs are (much) higher. The measures proposed here are only feasible if the (average) net household income rises. The idea behind this set of variants is that households may prefer 'quality to quantity'.

The results of the reduction measures for this group will be discussed in three sections: the purchase of products with an individualised design, the purchase of vegetables, fruit and meat grown ecologically and an increase in services rendered.

Table 5 shows the consequences of the purchase of furniture and clothes with an individualised design, a shift to food grown ecologically and services rendered. The following assumptions are made:

(a) The consequences of the purchase of furniture and clothes with an individualised design are assumed to affect the price per item, but not the energy requirement per item. The assumed price rise for furniture is 50%. It is assumed that 50% of the clothes double in price.

(b) We assume that 50% of the vegetables, fruit and meat are replaced by vegetables, fruit and meat grown ecologically, the price of which is about 50% higher (Beun and Leyen 1991). The effect on the energy requirement of this shift is not known and is assumed to be zero.

(c) According to (Wunderink 1993) about ECU 889 and 75 hours, of which about 10 hours (7%) are spent by a craftsman (who costs ECU 19 per hour) every year on house maintenance. It is assumed that 75% of the maintenance is farmed out by a craftsman. Because do-it-yourself maintenance also requires energy (e.g. transport), the net extra energy requirement per extra ECU spent on farming out maintenance work is assumed to be only 0,75 MJ (one third of the energy requirement per ECU on farmed out maintenance (Vringer et al. 1993b)).

(d) We assume that a domestic servant (fee: ECU 5,6 per hour (de Paauw and Perrels 1993)) is employed for 6 hours per week by 25% of the households. No extra energy requirement is assumed.

(e) We assume that an average household washes about 1.200 kg of laundry per year (derived from (van Dijk and Siderius 1992)). A washing machine, soap-powder and electricity are needed for 1.200 kg of laundry. The annual cost of soap-powder is ECU 56 (CBS 1992a) which involves an energy requirement of 0,9 GJ (Vringer et al. 1993b). The annual direct energy requirement for washing amounts 2,8 GJ (derived from (de Paauw and Perrels 1993) and costs ECU 25,50 (derived from (Vringer et al. 1993b). The total costs of do-it-yourself

washing, including the washing machine and excluding a tumble dryer, are ECU 123 and 3,9 GJ. A tumble dryer needs 127% of the direct energy requirement of a washing machine for the same amount of laundry (van Dijk and Siderius 1992). Assuming that the indirect energy requirement and costs are the same as for the washing machine, the annual costs of the do-it-yourself washing, including tumble dryer, are ECU 196 and 7,6 GJ (6,3 GJ direct and 1,3 GJ indirect).
The energy requirement for 1.200 kg of laundry washed by a laundry is assumed to be 10,7 GJ and ECU 1595 (derived from (de Paauw and Perrels 1993)).

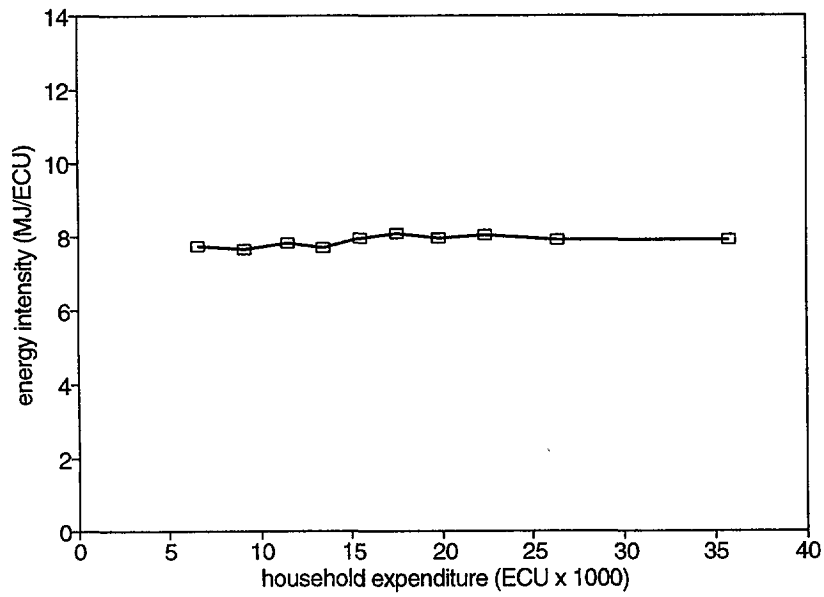
(f) We assume that the current average window-cleaning service (average annual costs in 1990 are ECU 18 (Vringer and Blok 1993a) is doubled but no extra energy is required. Window-cleaning service costs on average ECU 4,40 per time (de Paauw and Perrels 1993).Vringer et al. (1993a) mention a few more options (e.g. luxury food, alternative types of holiday residences) which have not been evaluated here because they do not contribute to a reduction in the energy requirement of households or because the contribution is uncertain.

Table 5. The consequences of the purchase of furniture and clothes with an individualised design, a shift to food grown ecologically and more services farmed out

	Energy requirement (GJ)	Expen-diture (ECU)	Extra En.req. (GJ)	Extra Exp. (ECU)	Assumptions
• purchase of furniture with an individualised design			-	148	(a)
• purchase of clothes with an individualised design			-	604	(a)
• the purchase of vegetables, fruit and meat grown ecologically (50%)				167	(b)
• farming out (more) house maintenance	-	889	0,7	978	(c)
• farming out (more) housework	-	76	0,0	433	(d)
• farming out (more) laundry	-	189	3,6	1400	(e)
• farming out (more) window-cleaning	-	18	0,0	18	(f)

6.3. Shifting consumption patterns whereby high energy intensive functions are replaced by low energy intensive functions

When the net household income rises over the next few decades, part of this expected extra household income may be used for products and services with a low energy intensity, instead of for the purchase of more of the same (Vringer and Blok, 1993a). This relation between energy intensity and the total household expenditure is shown in Figure 2, in which 10 income groups are plotted versus their indirect energy intensity.



The energy intensity for the indirect energy requirement remains fairly stable (approx. 8 MJ/ECU), even when the total household expenditure increases. Figure 2 suggests that an autonomous shift of the energy intensity (to a lower energy intensity), due to a shift in the consumption package, is not to be expected if the average net household income increases (see also the discussion).

In 1990 about 40% (Vringer and Blok 1993a) of the average household expenditure went on products and services with an energy intensity of less than 4,5 MJ/ECU. To calculate the effects of doubling expenditure connected with a low energy intensity, we exclude consumption categories with a low energy intensity which are connected with energy intensive activities (like car driving, pets). Also extra expenditure on a more expensive house is excluded, because in most cases this increases the direct energy requirement. The remaining is equal to 7,5% of the total household expenditure. Some categories that fall within this sector are camera's, compact disks, bikes, hairdresser, music lessons and telephone. If the amount spent on these consumption categories doubles the extra expenditure will be ECU 1.333 and will result in an extra energy requirement of 4,2 GJ.

7. DISCUSSION AND CONCLUSIONS

We refer to the limitations mentioned in section 5, where we gave a qualitative overview of the reliability of the assumptions made in this study. The most important uncertainty mentioned in section 5 is whether the proposed substitutions, reductions and shifts can be implemented. Also mentioned is the uncertainty about the energy requirement of several alternatives and the possible autonomous shift in the energy intensity if the average net household income increases. This means that this study has to be regarded as a "what might happen if ..." exercise. It can serve save as a guideline for further investigation of the indirect energy saving potential of (Dutch) households. Next we present the conclusions.

In table 6 the effects of the various possible actions on indirect energy requirement and expenditure are summarized. In the base year 1990 the indirect energy requirement of households was 130 GJ whereas the average (total) expenditure was ECU 17.825 (ECU 16.674, excluding the cost of natural gas, electricity and petrol). By implementation of the options discussed in this paper, a saving of 12 GJ (9% of the indirect energy requirement) can be achieved, even though the net income rises by approx. ECU 4.600. The indirect energy intensity of household expenditure decreases from 7,8 MJ/ECU to 5,6 MJ/ECU (-29%).
The substitution of products (part of the measures in category A) turns out to be a major category, but consists of a large number of different actions. The purchase of products or services which provide greater pleasure and/or comfort (category B) may reduce the indirect energy intensity but may increase the indirect energy requirement.
The reduction in (the growth of) indirect energy requirement of households that can be achieved in the way presented in this study is substantial and justifies further research. In such research the emphasis should be on studying the extent to which the shifts in consumption patterns are feasible and socially acceptable. In addition further energy analysis is required to more accurate figures.

Table 6 shows the total estimated reduction in the indirect energy requirement and the financial consequences.

Table 6. The total estimated reduction in energy requirement and the financial consequences

Option	extra energy requirement (GJ)	extra costs (ECU)
TOTAL	**- 12,0**	**4.569**
TOTAL OF CATEGORY A	**- 20,5**	**- 512**
Extending of the lifetime of	*- 2,5*	*-110*
• furniture(+50%)	- 0,4	0
• household appliances and tools (+100%)	- 1,6	- 62
• shoes (+500%)	- 0,5	- 48
Substitution of	*- 16,2*	*- 100*
• preserves	- 0,8	- 26
• vegetables from greenhouses	- 1,9	- 44
• import vegetables and fruit	- 0,4	0
• animal products	- 4,7	- 290
• disposable packaging of food-products	- 0,7	0
• flowers and plants from greenhouses	- 3,2	0
• synthetic floor-covering	- 0,4	121
• synthetic clothing	- 1,6	139
• holiday transport		
by aircraft and car	- 1,5	40
holiday transport distance	- 1,0	- 40
The sharing with other households of		
• cars - 0,9	- 222	
• caravans and boats	- 0,2	- 25
• tools - 0,2	- 8	
• newspapers and weekly papers	- 0,5	- 47
TOTAL OF CATEGORY B	**4,3**	**3.748**
• purchase of furniture with an individualised design	0	148
• purchase of clothes with an individualised design	0	604
• the purchase of ecologically grown vegetables, fruit and meat (50%)	0	167
• farming out (more) house maintenance	0,7	978
• farming out (more) housework	0,0	433
• farming out (more) laundry	3,6	1.400
• farming out (more) window-cleaning	0,0	18
TOTAL CATEGORY C	**4,2**	**1.333**
• more consumption with a low energy intensity	4,2	1.333

8. ACKNOWLEDGEMENTS

The authors wish to thank Sheila McNab for her linguistic assistance.
This study has been financed by the Ministry of Housing, Physical Planning and Environment of the Netherlands and the National Research Programme on Global Air Pollution and Climate Change (NOP-MLK). The work for the Ministry of Housing, Physical Planning and Environment was carried out as part of the preparation of the project "Perspective". In this project, ten households are given a higher monetary budget, but are required to stay within a limited energy budget.

9. REFERENCES

Beer, J.G. de, M.T. van Wees, E. Worrell, K. Blok. 1994. ICARUS-3: *the potential of energy efficiency improvement in the Netherlands up to 2000 and 1015.* Department of Science, Technology and Society. Utrecht University. Utrecht, The Netherlands.

Berger, B. 1993. "Schoenen krijgen steeds minder vaak een nieuw hakje (Shoes get new heels less often)". *Trouw,* 8 September 1993. (In Dutch)

Beun, M., J. Leyen. 1991. "Kritische consumenten gezocht: onbegrip en prijzen verzieken de biologische markt. (Looking for critical consumers: a lack of understanding and prices erode the ecological market.)" *Voeding & Milieu* 10(6):159-162. (In Dutch)

Bureau Goudappel Coffeng bv. (BGC). 1991. *Energiegebruik in verkeer en vervoer in cijfers.(Energy requirement of traffic and transport)* Deventer, The Netherlands. (In Dutch)

Centraal Bureau voor de Statistiek (CBS). 1991a. *Produktiestatistieken Industrie, tapijt- en vloermattenindustrie 1987 (Production statistics of the floor-covering Industry 1987) Voorburg/Heerlen, The Netherlands. (In Dutch)*

Centraal Bureau voor de Statistiek (CBS). 1991b. *Verblijfsrecreatie 1990, vakanties van Nederlanders. Residential recreation 1990, holidays of Dutch people.* The Hague, The Netherlands. (In Dutch)

Centraal Bureau voor de Statistiek (CBS). 1992a. *Budgetonderzoek 1990; micro bestand. (Netherlands Household Expenditure Survey 1990 computer file).* Netherlands Central Bureau of Statistics, Voorburg/Heerlen, The Netherlands.

Centraal Bureau voor de Statistiek (CBS). 1992b. Landbouwcijfers 1992 (Agriculture figures 1992). Voorburg/Heerlen, The Netherlands. (In Dutch)

Centraal Bureau voor de Statistiek (CBS). 1992c. *Auto's in Nederland, cijfers over gebruik, kosten en effecten* (Cars in the Netherlands, figures concerning usage, costs and effects, Voorburg/Heerlen, The Netherlands. (In Dutch)

Centraal Bureau voor de Statistiek (CBS). 1993. *Statistiek van de aan-, af- en doorvoer 1990 (Statistics for supply, removal and transport).* Voorburg/Heerlen, The Netherlands. (In Dutch)

Dijk, H.M.L. van, and P.J.S. Siderius. 1992. *Gebruiksregistratie van een aantal huishoudelijke apparaten (Registration of the use of household appliances).* SWOKA report no. 120. Leiden, The Netherlands. (In Dutch)

Engelenburg, B.C.W. van, T.F.M van Rossum, K. Blok and K. Vringer. 1994. "Calculating the energy requirements of household purchases. A practical step-by-step method." *Energy policy,* 22(8):648-656.

Jansen, R., M. Koster, B. Strijtveen. 1990. *Milieuvriendelijk verpakken in de toekomst. Een scenario voor 2001 (Future packaging, less harmful for the environment. A scenario for the year 2001).* Vereniging Milieudefensie. Amsterdam, The Netherlands. (In Dutch)

Kok, R., H.C. Wilting and W. Biesiot. 1993. *Energie-intensiteiten van voedingsmiddelen (Energy intensities of food).* Centre for Energy and Environmental Studies, State University of Groningen. Groningen, The Netherlands. (In Dutch, including update)

Miele, *Personal communication,* 26 April 1991.

Paauw, K.F.B. de, and A.H. Perrels. 1993. *De energie-intensiteit van consumptiepakketten (The energy intensity of consumption packages).* Netherlands Energy Research Foundation. Petten, The Netherlands. (In Dutch)

Perdijk, E. *Personal communication.* Communicatie En Adviesbureau over energie en milieu (CEA). Rotterdam, 30 September 1993.

PGF, Produktschap voor groenten en fruit, Stichting propaganda groente en fruit. *1990 Jaarverslag 1990 (Annual report of the Foundation for the promotion of vegetables and fruit).* Den Haag, The Netherlands. (In Dutch)

Potting, J., K. Blok. 1993. *De milieugerichte levenscyclus analyse van vier typen vloerbedekking. De beoordeling op milieu-effecten in de levenscyclus van linoleum, verende vinyl vloerbedekking, getuft tapijt met een wolpool en een getuft tapijt met een pool van polyamide. (The environmental life-cycle analysis of four types of floor-covering. An evaluation of the life-cycle analysis of linoleum, vinyl, woollen and polyamide floor-coverings).* Cordinatiepunt wetenschapswinkels Utrecht. Utrecht, The Netherlands. (In Dutch)

Rijsdorp, I., J. Guinee, G. Huppes. 1989. *Milieu-effekten van huishoudelijke verpakkingen (Environmental effects of the packaging of consumption goods).* Centrum voor Milieukunde. Leiden, The Netherlands. (In Dutch)

VEEN, Vereniging Elektriciteits Exploitanten Nederland. 1990 Energiewijzer 1990 1991, washing machines. (In Dutch)

Vringer, K. and K. Blok. 1993a. *The direct and indirect energy requirement of households in the Netherlands.* Department of Science, Technology and Society. Utrecht University. Utrecht, The Netherlands.

Vringer, K. and K. Blok. 1993b. *Energie-intensiteiten van de nederlandse woning (The energy intensities of Dutch houses).* Department of Science, Technology and Society, Utrecht University. Utrecht, The Netherlands. (In Dutch)

Vringer, K. J. Potting, K. Blok. and R. Kok. 1993a. *Onderbouwing reductiedoelstelling indirect energieverbruik huishoudens; voor een demonstratieproject levensstijlen en energieverbruik (Estimations of a target for the reduction of the indirect energy requirement of households in connection with a Demonstration Project Lifestyles and Energy Requirement).* Department of Science, Technology and Society. Utrecht University and the Centre for Energy and Environmental Studies, State University of Groningen. Utrecht, The Netherlands. (In Dutch)

Vringer, K., J. Potting and K. Blok. 1993b. *Energie-intensiteiten van de Nederlandse huishoudelijke inboedel (The energy intensities of Dutch household effects).* Department of Science, Technology and Society, Utrecht University. Utrecht, The Netherlands. (In Dutch)

Wilting, H.C. 1992. EAP, *Energie Analyse Programma (Energy Analysis Programme).* Centre for Energy and Environmental Studies, State University of Groningen (IVEM-RUG). Groningen, The Netherlands.

Wunderink, S.R. 1993. "Woningonderhoud, uitbesteden of doe-het-zelven? (House maintenance: farm out or do-it-yourself?)" *Economisch statistische berichten*, 78(no:3923).