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

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Abstract

Like all consumer products, cut flowers require fossil energy during their life cycle. The aim of this article is to examine how households can reduce their energy requirement for the decorative and gift functions of cut flowers without reducing their consumption level, also taking into account the financial cost.

In 1990, an average Dutch household purchased 11 times one or more bouquets containing a total of about 250 flowers for Dfl. 170, which require together about 2.2 GJ, 1% of the total household energy requirement. The energy intensity of flowers is among the highest of all non-energy household purchases: on average 12.9 MJ/Dfl. The high energy requirement of cut flowers makes it interesting to take a closer look at less energy-intensive alternatives, like replacing flowers as a gift with other presents, making more use of flowering indoor plants and selecting less energy-intensive flowers (from abroad, other species, other seasons). The calculations suggest that if all the energy reduction options discussed here are applied to a substantial extent, the cumulative energy required for flowers purchased by an average Dutch household can be halved. More research is needed to investigate the acceptance of the proposed measures and the feasibility of a combination of measures.

Introduction

The production and distribution of all consumer products require energy during their life cycle, which generally leads to CO_2 emissions. According to Vringer and Blok (1995) about half of the energy requirement of Dutch households is related to energy carriers like electricity, petrol and natural gas (direct energy requirement). The other half is embodied in the consumed products and services (indirect energy requirement). These products and services have different energy intensities[1]. Replacing products and services by less energy-intensive products and services can reduce the total household energy requirement and the concomitant CO_2 emissions. In this article we will focus on cut flowers for exploring the possibilities of such replacements. Initial calculations of indirect energy requirements for cut flowers and indoor plants of Dutch households in 1990 show a relatively high energy requirement of 4.3 GJ per household, nearly 2% of the total household energy requirement. The energy intensity of flowers and indoor plants was found to be one of the highest (about 15 MJ/Dfl.) of all consumer products. Only the energy carriers used by households (petrol, electricity and natural gas) have a higher energy intensity of 22, 49 and 59 MJ/Dfl, respectively (Vringer and Blok, 1995). The generally high energy intensity of cut flowers and indoor plants makes it interesting to take a closer look at less energy-intensive alternatives. In this article we focus only on cut flowers.
As we will see, cut flowers are used as household decorations and they also play an important role as gifts. The aim of this article is to examine the extent to which households can reduce their energy requirement by using alternatives to fulfil these decoration and gift functions. We first discuss the role of cut flowers and indoor plants in the total resources needed for household decoration. Next, we determine the energy required for cut flowers in terms of type and season of purchase. Finally, we discuss the household function of flowers and quantify energy reduction options for household decoration and gifts.

[1] Energy intensity is the total primary energy requirement divided by the consumer price and is expressed in MJ/Dfl. All monetary quantities are expressed in Dutch guilders (Dfl.). One Dfl is about 0.45 euro or 0.6 US$ as of 1995.

The role of cut flowers and indoor plants in household decoration

Many activities are carried out in households and household decoration is one of them. This activity consists of all actions, deliberations, and decisions needed to decorate the house (Groot-Marcus et al., 1996). For the activity of household decoration, several resources are required, mainly time and money[2]. In this section, we describe the requirements of the resources of household time and money. The resources described here for household decoration include all time and money needed to furnish the house and garden. Also, the resulting energy requirements are given. These figures include requirements for furniture, upholstery, shopping and transport (to obtain the relevant products), house cleaning, waste disposal and wall decoration. Resources for heating and lighting the house are excluded. Financial expenditure (S) for the relevant consumption categories (i) is derived from the 1990 Dutch family budget survey (CBS, 1992). Expenditure of time is derived from the 1990 Dutch time expenditure survey (TBO, 1990). The total household energy requirement (E) is calculated according to formula (1). Energy intensities (ε) are from Vringer and Blok (1995).

$$E = \Sigma (S_i * \epsilon_i) \qquad (1)$$

The time, money and the calculated energy requirements for average Dutch household decoration in 1990 are given in Table 1[3]. Expenditures for the consumption categories of transport (for shopping), water (for cleaning), domestic services (for cleaning) and direct energy requirements (for cleaning), given by CBS (1992) and TBO (1990) are for the relevant portion attributed to the activity of household decoration. Expenditures for these partial attribution categories are jointly responsible for Dfl.380 and 4 GJ.

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[2] Groot-Marcus et al. (1996) mention more household resources like 'goods facilities' (in this case, vases, pots, plant food, potting compost), 'space' (in this case, for the flowers and plants themselves), 'knowledge', 'skills' and 'labour capacity'. These resources are not regarded as important factors for alternatives and are not further analysed in this article.

[3] The time expenditure in Table 1 is given per person above 12 years of age. The average household has 2.2 household members above this age (CBS, 1992). To calculate the average time expenditure per household, time expenditures given in Table 1 have to be multiplied by 2.2.

Table 1. Time, money and energy requirements for average Dutch household decoration in 1990.

	Energy requirement (GJ/hh yr)	Financial expenditure (Dfl/hh yr)	Time expenditure (min/person wk)	Energy intensity (MJ/Dfl)
Garden	2.0	241	47	8.3
Flowers and plants	4.4	279	17	15.6
Furniture	5.3	1334	-	4.0
Upholstery	0.4	79	-	4.6
Cleaning[4]	3.2	349	150	9.1
Shopping	0.4	58	30	7.2
Other	1.4	252	32	5.4
Total	17.1	2592	276	6.6
Percent of total	7%	6%	3%	

Table 1 shows that household decoration required nearly Dfl.2600 (6% of the average net income), 17 GJ (7% of the average total household energy requirement) and 4.6 hours per person per week (3% of the total time expenditures) per average household in 1990. Cut flowers and indoor plants are responsible for 11% of the financial expenditures, 26% of the energy requirement and 6% of the time expenditures for household decoration. The energy intensity of cut flowers is twice that of the average energy intensity for household decoration.

[4] Includes cleaning agents and cleaning apparatuses, domestics and electricity, natural gas and water in so far as used for cleaning the house.

Energy requirement of cut flowers

We determined the cumulative energy requirements for 37 of the most common cut flowers grown in the Netherlands, as a function of the season of purchase. The data required for the energy analysis is from IKC-GenB (1991), which gives costs calculations for many sorts of cut flowers, divided into the required expenditures for decontamination, herbicides, water, packaging, transport to the auction, interest, depreciation and auction. Also, the expected selling price, number of cut flowers produced[5] and natural gas and electricity requirements (for heating the greenhouse and assimilation lighting) are given for the 13 4-week periods in a year.
To calculate the energy requirements for flowers, energy intensities for all cost items are needed. These energy intensities are calculated with the EAP computer programme (Wilting, 1995), which is based on hybrid energy analysis[6] as described by Van Engelenburg et al. (1994). EAP also contains all additional necessary input-output data. Table 2 shows the calculated energy intensities for all cost items, which are used for the energy analysis for cut flowers.

Table 2 Calculated energy intensities for cost items of cut flowers. Energy intensities are expressed as the primary energy requirement per unit purchased.

Cost item	Energy intensity	Unit
Natural gas	32.0	MJ/m^3
Electricity	10.3	MJ/kWh
Seeds	21.1	MJ/Dfl.
Preparation	7.5	MJ/Dfl.
Fertilisation	54.1	MJ/Dfl.
Pot / container	11.5	MJ/Dfl.
Potting compost	3.0	MJ/Dfl.
Other materials	11.5	MJ/Dfl.
Insecticide / weed killer	7.9	MJ/Dfl.

[5] In this article, one stalk is equal to one flower. Some kinds of flowers have more flowers on one stalk.

[6] The hybrid energy analysis method allows the cumulative energy requirement of a consumption item to be calculated relatively easily and accurately way. This is achieved by combining the best elements of two existing methods for determining the cumulative energy requirements of goods and services: process analysis and input-output analysis.

Cold store	10.0	MJ/Dfl.
Packaging	11.5	MJ/Dfl.
Auction	2.2	MJ/Dfl.
Interest	0.2	MJ/Dfl.

To calculate the energy requirements for flowers, expenditures according to IKC-GenB (1991) are multiplied by the energy intensities in Table 2. Finally, the energy requirements for retailing and transport are added. The retailing of flowers and plants requires 3.8 MJ per Dutch guilder added value, and cut flowers are sold on average for 165% of the purchase price (Wilting et al., 1995). The energy requirement per flower can be calculated with this information.
To factor in the influence of the season in which the flowers are purchased, we attributed to the flowers purchased in a certain 4-week period the energy requirement to heat and light the greenhouse of the 4-week period and as well as that of the two preceding 4-week periods and divided by three. The 8 extra weeks are taken into account because flowers usually need about 8 weeks to grow (Vermeulen, 1995).

Seven of the 37 analysed cut flowers are bulbous flowers like Tulips, Hyacinths and Lilies. Ref. IKC-GenB (1991) gives no extended figures for bulbous flowers, but Elderman (1994) provides the total natural gas required for cultivating a certain amount of several kinds of bulbs. The amount of natural gas given by Elderman (1994) needed for cultivation is distributed over 13 4-week periods, as is done by IKC-GenB (1991) for the other cut flowers described. To take into account the time a bulbous flower needs to grow, the energy requirement attributed to heating is based on average energy requirements in the relevant period and the preceding 4-week period. Furthermore, we assume that all other steps in the production and distribution process of bulbous flowers require 3 MJ of primary energy per flower, equal to the average energy required by cut flowers grown outdoors the greenhouse. We also assume that the cultivation of one bulb results in one flower.

Figure 1 shows the variation in energy, required per month for four of the most sold cut flowers. The appendix contains the season-dependent energy requirements and energy intensities for all flowers analysed in all 13 4-week periods of the year.

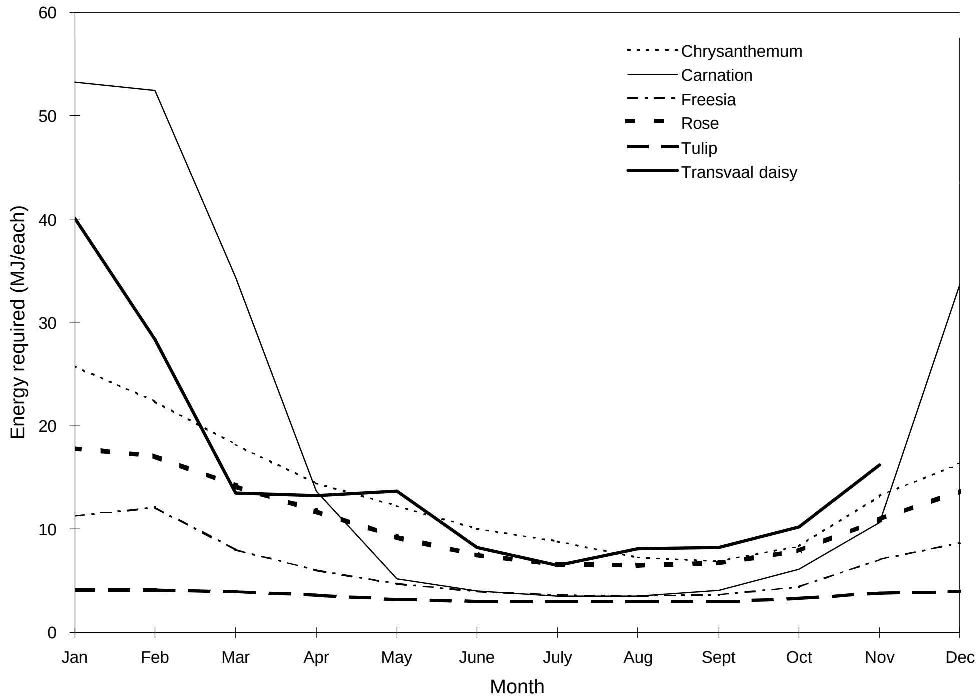

Figure 1. The seasonal variation of the primary energy required for 6 of the most sold cut flowers.

The energy requirement and energy intensity varies considerably per month purchased and per type of flower. We found variation in the energy requirement ranging from 3 to 195 MJ per flower. Flowers grown outdoors generally require about a quarter of the energy consumed by flowers grown in a greenhouse, but greenhouse flowers are available the whole year. The energy intensity of some flowers like bouvardia, Peruvian lily and carnation in wintertime is higher than that of natural gas[7]. In wintertime, flowers like carnation require each an amount of primary energy, equal to 1 to 1.5 litre of petrol[8].

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[7] The energy intensity of natural gas as sold to households is about 60 MJ/Dfl (Vringer and Blok, 1995). The energy intensity of these flowers can be higher because natural gas prices for greenhouse horticulture are much lower than those for households.

[8] One liter petrol requires 35 MJ (Wilting et al., 1995).

Most Dutch auction sales are destined for export[9]. However, auction sales according to CBS (1994) accurately represent the composition of flower types purchased by Dutch consumers according to Ten Hag and Van der Ham (1996). By using auction sales of 15 of the most commonly sold flowers (CBS, 1994), we calculated the average energy requirement and energy intensity for these flowers, taking into account the period of auction, and the energy requirements per type of flower. Table 3 shows the results.

Table 3 Percentage of auction sales, consumer price, energy requirement per flower and energy intensity for the 15 most auctioned types of flowers.

Sort of flower	Auction sales (% flowers sold)	Consumer price (Dfl/each)	Energy requirement (MJ/each)	Energy intensity (MJ/Dfl.)
Peruvian lily	2.7%	0.8	15.0	19.1
Flamingo flower	0.4%	3.1	51.6	16.8
Michaelsmas daisy	1.0%	0.9	10.9	12.8
Chrysanthemum	18.1%	0.8	12.5	14.8
Carnation	7.3%	0.6	4.9	7.9
Freesia	8.2%	0.4	6.5	14.9
Transvaal daisy	5.3%	0.7	13.4	20.5
Baby's breath	1.6%	0.8	7.9	10.4
Amaryllis	0.9%	0.7	10.7	15.7
Rose	29.8%	0.6	9.5	16.2
Tulip	12.7%	0.7	4.0	5.4
Iris	3.1%	0.5	4.5	9.9
Lily	4.8%	1.2	8.1	6.8
Daffodil	2.3%	0.4	3.6	10.0
Sword lily	1.7%	0.3	3.0	11.7
Auction sales weighted average		0.7	8.8	12.9

Table 3 shows that the average energy requirement per flower is about 9 MJ and the average energy intensity about 13 MJ/Dfl. An average household in 1990 spent Dfl.280 on flowers and indoor plants (CBS, 1992). About 60% of this amount was spent on flowers (Ten Hag and Van der Ham, 1996; Van der Velden, 1997). This brings the total expenditure per average household in 1990 to Dfl.170, for which 11 times one of more bouquets, containing a total of about 250 flowers, are bought (Bertens et al., 1997). Assuming that

[9] In 1990, 70% of the cut flower production in the Netherlands was for export. Also in 1990, the Netherlands was responsible for nearly 60% of the total export of flowers worldwide (Hack

the average energy requirement of all flowers is the same for these 15 sellers, then the total energy requirement amounts to 2.2 GJ. Together, chrysanthemums and roses are responsible for half of all flowers purchased and 60% of the average household energy requirement for cut flowers.

Figure 2 shows the average energy requirement and energy intensity for the 15 best sold flowers, assuming that the price of the bulbous flowers varies in the same way each month as the unweighted average price of the other 30 cut flowers analysed. Compared to Figure 1, the seasonal effect of the energy requirement is reduced because flowers exhibiting high energy consumption are mainly sold in summertime and vice versa. Also the energy intensity in summertime is not much lower than in wintertime, due to lower summertime prices.

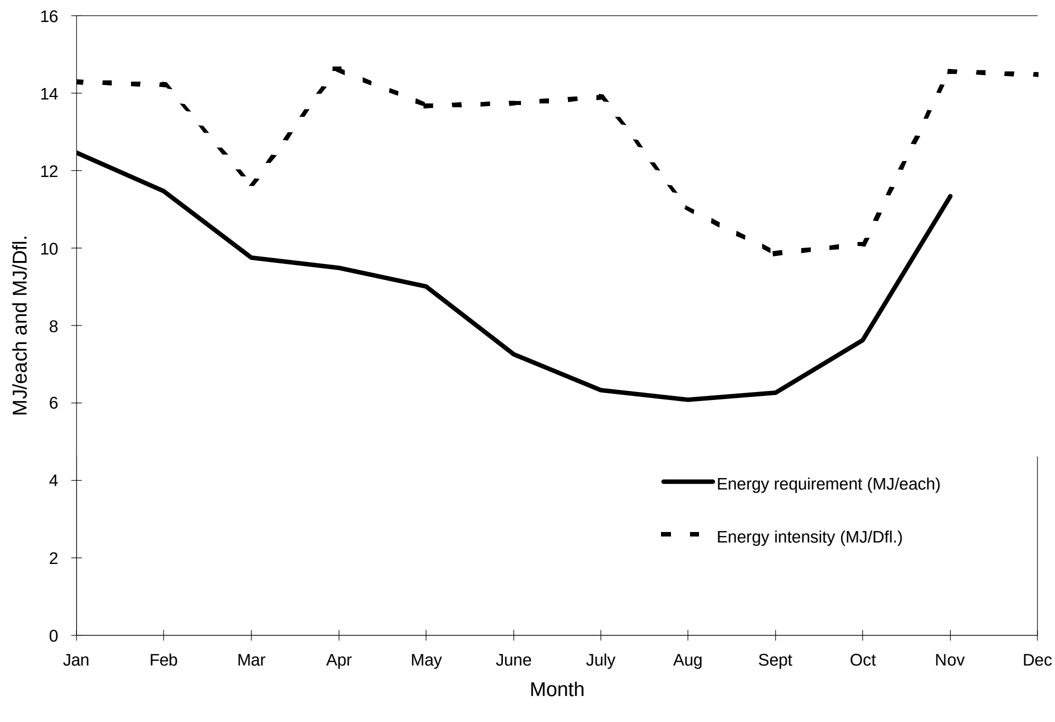

Figure 2. Average energy requirement and energy intensity for the 15 most commonly grown flowers in the Netherlands.

and Heybroek, 1992).

Functionality of cut flowers and consumption characteristics

Before we can start analysing energy reduction options, we have to elaborate on the functionality of cut flowers, as this is relevant to the degree to which alternatives are feasible. In general, we may distinguish two functions for cut flowers: to decorate one's own house and as a gift.
Ultimately, cut flowers are (finally) used in most cases to decorate the house. But, flowers are not suitable for all household decoration. Cut flowers often decorate a table, but households more frequently use indoor plants for the decorating windowsills (Van Tilburg, 1984).
In the Netherlands, flowers are the most popular gift (Komter and Schuyt, 1993; Van der Velden, 1996). Flowers represent about 30% of the smaller presents[10] (van der Velden, 1996). About 50% of all flowers are purchased as present for an average price of Dfl.15 (Ten Hag and Van der Ham, 1996).

In 1995, 70% of the households in the Netherlands bought flowers (Ten Hag and Van der Ham, 1996). About 20% of the purchases were unplanned, while 75% who planned to buy flowers
have no specific type of flowers in mind before the actual purchase (Van Tilburg, 1984). No relation was found between the kind of house (flat or detached house with a garden) and expenditures on flowers and indoor plants (CBS, 1996). But there is a relation between household expenditures on cut flowers and indoor plants and total net household income. Households with twice the average net income spend 70% more on flowers and indoor plants than households with an average net income (CBS, 1996). However, the spread of flower expenditures is wide for households in one income category.

[10] Up to Dfl.30

Reduction options

In this section we describe consumer energy reduction options for household decoration and gifts consisting of cut flowers. All the options can be instituted nowadays by households themselves. So, we exclude energy reduction options that can be carried out by others like growers and retailers. If the energy reduction options described are applied, the total number of functional units will be kept as much as possible the same. A functional unit is defined as one gift or one decorate item, in most cases comparable to one bouquet of flowers.
First, the maximum annual energy reduction per option is calculated for an average Dutch household. If relevant, the impact on expenditures is calculated. Finally, the constraints of the reduction options are discussed in a tentative way.

We divided the energy reduction options into two main groups:
- Replacement by other kinds of the same category of products
- Replacement by other products with a comparable function

These two groups of options and the maximum energy reduction are discussed next. Table 6 gives an overview of all options discussed, including additional constraints.

Replacement by other kinds of the same category of products
There is a number of ways for households to reduce the energy requirement for cut flowers, without replacing them with other sorts of decorative items. The following options are discussed:
- Buy more cut flowers in the summertime and less in wintertime
- Buy less energy-intensive cut flowers
- Extend the lifetime of cut flowers by proper treatment
- Buy cut flowers grown by environment-friendly methods
- Buy cut flowers grown in warm countries, instead of Dutch cut flowers
- Buy bulbs instead of bulbous cut flowers.

Buy more cut flowers in the summertime and less in the wintertime.
A shift in purchasing season can reduce the energy requirement of flowers. If a part of all purchased flowers (see Figure 2) is not bought in wintertime but

only in summertime[11], the energy requirement for cut flowers decreases by 20%[12]. The average weighted price of the 15 most common flowers in summertime is about 14% lower than the average for the whole year. Assuming that the month of purchase cannot be changed for gifts (50% of all flowers bought are gifts (Ten Hag en Van der Ham, 1996)), the maximum achievable energy reduction for cut flowers for an average Dutch household is 10%, 224 MJ/year. The reduction of expenditures is then Dfl.12/year.

Buy less energy-intensive cut flowers.

A shift to less energy-intensive flowers can reduce the total energy required for flowers for some households. Table 3 shows that the average energy requirement per flower is 8.8 MJ, varying from 3 to 51 MJ. The four flowers with the highest energy requirement each are chrysanthemums, Transvaal daisies, Peruvian lilies and Flamingo flowers, which all require more energy than 11 MJ/each. About 66 of these 4 sorts of flowers are purchased per Dutch household per year. If chrysanthemums are replaced by Michaelsmas daisies, Transvaal daisies by carnation, Peruvian lilies by Lilies and Flamingo flowers by Amaryllis, the energy required per flower decreases on average by 30%. We assume that this measure is only applicable to 85% of all flowers bought by households that do not always have flowers in their house[13]. We also assume that this option is applicable for both flowers bought for household decoration and flowers purchased as gifts. The energy reduction is then about 10%, 231 MJ per year for an average household. The expenditures will remain unchanged.

Households who always have flowers can reduce their energy requirement by buying cut flowers with a longer lifetime. Table 4 shows the lifetime of 15 best selling species under optimal conditions. Also, the energy required per flower per day has been calculated. Assuming that the flowers receive optimal treatment, not using food for cut flowers, the average energy required per flower per day is about 1.1 MJ. We assume that less energy-

[11] Summertime is here defined as the period between 1 May and 31 October and wintertime as the period between 1 November and 30 April.

[12] Average energy requirement per flower for the whole year is 9 MJ/each; average energy in summertime is 7 MJ/each. About 46% of all flowers is sold in wintertime.

[13] A household has to make 3.4 flower purchases per month in order to renew a bouquet of cut flowers immediately after an average (optimal) lifetime of 8.9 days (see Table 5). Households who buy flowers 7 times or more per month, buy about 30% of all flowers (Bertens et al.,1997), but only half of these purchases is to decorate one's own house. So it can be assumed that about 15% of all cut flowers purchased are immediately replaced when they die.

intensive flowers will replace the 4 flowers requiring the most energy per flower per day.
Flamingo flowers are replaced by Amaryllis, Peruvian lilies by Lilies, Transvaal daisies by carnations and large roses by carnations. Taking into account that this option is only valuable for 15% of all flowers purchased, the average energy requirement of cut flowers decreases by 2% (37 MJ per year per average household). The expenditure will remain be unchanged. The various lifetimes of the three sorts of replacement flowers are taken into account.
The total effect of this option for all flowers purchased is a reduction of 12%, 268 MJ.

Table 4. Lifetime under optimal conditions (Nieuwenhoven, 1998) and the energy requirement
per each flower and per day per flower for 15 of the best common flowers.

	Lifetime	Energy requirement	Energy requirement Per day
	(days)	(MJ/each)	(MJ/each/day)
Peruvian lily	8.5	15.0	1.8
Flamingo flower	17.5	51.6	2.9
Michaelsmas daisy	8.5	10.9	1.3
Chrysanthemum	14	12.5	0.9
Carnation, small	10	4.9	0.5
Carnation, large	8	4.9	0.6
Freesia	7.5	6.5	0.9
Transvaal daisy	8.5	13.4	1.6
Baby's breath	6	7.9	1.3
Amaryllis	10	10.7	1.1
Rose (small)	8.5	9.5	1.1
Rose (large)	6	9.5	1.6
Tulip	6	4.0	0.7
Iris	3.5	4.5	1.3
Lily	8	8.1	1.0
Daffodil	4	3.6	0.9
Sword lily	8	3.0	0.4
Average	8.9	8.8	1.1

Extend the lifetime of cut flowers by proper treatment.
Proper treatment (clean vases, clean water, no sunshine, fertiliser, etc.)

extends the lifetime of cut flowers substantially. Adding fertiliser extends the lifetime of Michaelsmas daisies, carnations (small), Freesia and roses by about 30%. Together, these four types account for 44% of all flower-days[14] (see table 4). For other types extension of lifetime by fertilising is less advantageous. (Nieuwenhoven, 1998). There are no figures on actual treatment of flowers in households. The effect of better treatment is based here only on lifetime extension obtained by fertilising Michaelsmas daisies, carnations (small), Freesia and roses. Taking into account that this option only works for 15% of all purchased flowers that are replaced immediately at the end of their lifetime, the average energy requirement of cut flowers decreases by 2% (41 MJ per year per average household), while expenditures decrease by Dfl.3. The various lifetimes of the 3 types of replacement flowers have been taken into account. We assume that extra costs for fertiliser are neglectable.

Buy cut flowers grown with environment-friendly methods.
Environment-friendly growers in the Netherlands try to reduce energy required for growing their cut flowers. But there are no unambiguous standards for the energy required for these flowers, and nor are there signs that these flowers are grown more efficiently (Franke, 1995; Sperling, 1995; Heeze, 1995). Environmental-friendly flowers have benen experimentally launched on the Dutch market and they cost between 10% and 30% more than the cut flowers grown by regular methods (Van der Velden, 1998a; Sperling, 1995). Calculations of the energy requirement of ‘green flowers’ could not be made because of lack of data. We excluded this option in further calculations.

Buy cut flowers grown in warm countries, instead of Dutch cut flowers.
Imported flowers from countries like Kenya, Israel, Spain and Morocco can be grown in a more energy-efficient way than in the Netherlands because of their relatively warm climate. The energy required for roses grown in Israel, Morocco and Spain is about 10% less than in the Netherlands, including the energy required for air transport (about 1 MJ/flower). This relative light difference in energy requirement per rose is mainly due to the relative low flower production per square metre in these warmer countries. Compared with the Netherlands, the production of roses per square metre is 50% lower

[14] A flower-day is the presence of one cut flower in the house for one day. The lifetime of a small rose is 8.5 days (see Table 5). So, ten small roses are good for 85 flower-days.

in Israel and 75% lower in Spain and Morocco (Verhaegh, 1996). Figures for other sorts of flowers are unavailable (Van der Velden, 1998b). Flowers from Kenya are generally not grown in heated greenhouses (Kortlandt, 1998). The total energy requirement of Kenyan roses is about 2 to 3 MJ per rose, including transport (Lenggenhager, 1997[15]), 85% less than Dutch roses. We assume that the prices of imported flowers are comparable with flowers grown in the Netherlands. Van Vliet (1998) and Van der Velden (1998b) expect that the energy requirement for Kenyan flowers to rise, due to advances in flower cultivation. A reduction of the required energy by at least 10% and maybe up to 85%, due to buying flowers from warm countries seems feasible. The energy required for air transport of flowers is relative insignificant (1 to 3 MJ per flower).

[15] For the calculation, we used figures for the same sort of rose (First Red) out of the appendix in Lenggenhager (1997). We also included the energy needed for the production of electricity (total 10.3 MJ/kWh; see Table 2).

Buy bulbs instead of bulbous cut flowers.
Buying bulbs instead of bulbous cut flowers saves the energy required for breeding the bulbs. The energy required to breed one bulb is about 1 MJ, except for lilies, which is 6 MJ per bulb. The total average energy required for bulbous flowers is 3 to 4 MJ/each, except lilies, at 9 MJ/each. The energy reduction, which can be achieved by buying bulbs instead of bulbous flowers, is about 10% per bulb and about 60% for lilies[16]. Total energy reduction amounts to 80 MJ, about 4% of the total energy required for all cut flowers purchased per average Dutch household. Reduction of expenditures is not expected.

Replacement by other products with a comparable function
Households can reduce the energy requirement for cut flowers by replacing flowers with alternative decorations. The following options are discussed:

- Buy indoor plants instead of cut flowers
- Buy plastic/textile flowers instead of cut flowers
- Buy art like paintings and sculptures instead of cut flowers
- Buy alternative presents

Buy indoor plants instead of cut flowers.
Indoor plants have a much longer lifetime than cut flowers. If indoor plants can replace the relative short living cut flowers, a reduction of energy requirement can be achieved. The average number of cut flowers in the house, including gifts, is about six per day, on average about half a bouquet at a time. This means that on average all cut flowers in a household can be replaced by one indoor plant. If we assume that the average flowering time of the replacing flowering indoor plants is two times for three weeks, about eight plants are needed per year to replace all cut flowers, including flowers obtained as gifts.
We assume that the energy required for one flowering plant is equal to that of a 60 cm Ficus benjamina[17]: 50 MJ each (Potting et al., 1995). The replacement of all flowers by indoor plants, excluding flowers purchased for a present, saves 0.9 GJ per year, 41% of the annual energy requirement per average Dutch household for cut flowers. The energy intensity of indoor

[16] We added extra energy, required for the pot in which in most cases more bulbs (we assumed four) are sold. The energy required for a plastic pot with a diameter of 14 cm is estimated at 2 MJ (Potting et al., 1995).
[17] We chose Ficus benjamina because it is one of the most sold larger indoor plants at the auction (CBS, 1994)

plants is about equal to that of cut flowers (Potting et al., 1995), which means that financial expenditures decreases by 41%.

Buy plastic/textile flowers instead of cut flowers.
Replacing cut flowers with imitation flowers made of plastic or cloth with a much longer lifetime can reduce the energy required dramatically. We assume that the daily average of 6 flowers in the house will be replaced by 10 high-quality imitation flowers with a lifetime of 10 years, costing Dfl.10 each and having a total weight of 0.5 kg nylon. The energy required for these 10 high-quality imitation flowers is calculated to be about 500 MJ (calculated with Wilting et al., 1995). The reduction of the required energy is then about 48% (excluding flowers purchased for a present) and can save Dfl.75 per year.

Buy art like paintings and sculptures instead of cut flowers.
Art decorations like paintings and sculptures can replace a bouquet of flowers. If all flowers are replaced by art that costs the same price and the lifetime of this art is 20 years, a household can spend Dfl.2080[18]. We assume that the energy intensity of art is equal to 1 MJ/Dfl. If all flowers are replaced by art, excluding flowers purchased for presents, the annual net energy reduction will be about 48% of the total energy requirement for cut flowers.

Buy alternative presents.
Flowers are not only used to decorate the house; 50% is bought as a present. The average price of flowers given as a present is Dfl.15 (Ten Hag and Van der Ham, 1996). If households do not buy flowers for gifts anymore and choose for the same price a mix of the other most common presents (see Table 5) with an (unweighted) average energy intensity of about 3 MJ/Dfl., 39% can be saved.

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[18] Net present value of the annually expenditure of Dfl.170 for 20 years, including an inflation rate of 3% per year and 8% interest.

Table 5. Top 10 of the most common presents (Komter and Schuyt, 1993) and their energy intensity (Vringer and Blok, 1995).

	Present	Energy intensity
0	Flowers	12.9
1	Food (bonbon, sweets)	5
2	Toys	3
3	Cosmetics, finery	2-3
4	Liquor	1-4
5	Books	2
6	Gift voucher	2
7	Household articles	3
8	CDs	2
9	Crockery	3
10	Clothes	3

Overview of energy reduction options

Table 6 gives a summary of the maximum achievable reduction of energy requirement for the options discussed. But every energy reduction option has more constraints due to limited acceptability of the various options for the consumer: alternatives may have different functionality. Data on these constraints is unavailable. We have made the following rough assumptions of the effect of the constraints, based on an expected willingness of consumers:

- For the three reduction options: lengthening the lifetime of flowers by adding fertiliser and a shift to less energy-intensive flowers, we assume that 75% of the maximum reduction is achievable. Most consumers decide the kind of flowers they will buy at the place of purchase (Van Tilburg, 1984). Only when buying and putting the flowers in a vase is some effort required from consumers.
- From the maximum achievable shift from bulbous flowers to bulbs and from cut flowers as presents to alternative gifts, 50% is assumed to be really achievable. These options induce a change of product, which may require greater effort from consumers, and may be less acceptable due to changes in functionality.
- From the maximum achievable shift in the purchase season from wintertime to summertime and from cut flowers to indoor plants 25%, is assumed to be really achievable. These options show a larger shift in decorative functionality than the previous solution and may be less acceptable.

- From the maximum achievable shift from cut flowers to artificial flowers and from cut flowers to art like paintings and sculptures, only 5% is assumed to be achievable. It is very plausible that the artificial aspects of the plastic or textile flowers are unacceptable to many people. Also art is not in demand by many people because of the large difference in functionality, compared with flowers.
- For flowers from warmer countries, we assume that -for the time being- the availability of high-quality flowers on the market will be limited and that this will limit replacement rates to 50%.

Including all constraints, the total energy reduction per average household will be about 1 GJ per average household if all options are applied. This is about half of the annual energy required for cut flowers. Also, about Dfl.25 will be saved. If this Dfl.25 is spent on average goods[19], energy reduction is affected by about 0.1 GJ.

Again it should be emphasized that no data is available on the feasibility of these options and that the calculation should be considered as an analysis of *what* can happen *if* the options discussed here, are applied to a substantial extent.

[19] The average energy intensity of goods and services (excluding natural gas, electricity and petrol) is 3.5 MJ/Dfl. (Vringer and Blok, 1995).

Table 6. Overview and effects of the discussed options to reduce the energy requirement and expenditures of an average Dutch household. The achievable reductions are established in a tentative way.

Option	Maximum effect on the energy requirement for cut flowers (percentage)	(MJ/year)	Maximum effect on expenditures (Dfl./year)	Estimated potential, due to contraints	Effect on energy requirement (MJ/year)	Effect on expenditures (Dfl./year)
Replacement by other types of products of the same category						
Buy cut flowers in the summertime *	-10%	-224	-12	25%	-56	-3
Buy less energy-intensive flowers	-12%	-268	0	75%	-201	0
Extend the lifetime of cut flowers by adding fertiliser	-2%	-41	-3	75%	-30	-2
Buy cut flowers grown with environment-friendly methods	0%	0				
Buy imported cut flowers instead of Dutch cut flowers	- 10 / - 85%	-220 / -1870	0	50%	-281	0
Buy bulbs instead of bulbous cut flowers	-4%	-80	0	50%	-40	0
Replacement by other products with a comparable function						
Replace cut flowers with indoor plants	-41%	-900	-70	25%	-225	-17
Buy plastic/textile flowers instead of cut flowers *	-48%	-1050	-75	5%	-52	-4
Buy art like paintings and sculptures instead of cut flowers *	-48%	-1047	0	5%	-52	0
Do not buy flowers for a present, but alternative gifts	-39%	-860	0	50%	-430	0
Total, corrected for overlap of effects from individual measures					-1067	-25

* For these options, we took into account the unsuitability of replacing flowers bought as a gift.

Discussion

Several comments should be made about the results. First, we discuss the uncertainties in calculating the energy required for cut flowers. Then, the uncertainties of the reductions options are discussed. Finally, some additional comments are made.

Regarding the calculation of the energy required, we have the following comments:

1. In this study, the energy required for cut flowers is partly calculated with an input-output energy analysis. Input-output analysis is less accurate because the energy is assigned on a financial basis and not on a physical basis. However, the possibility for error is limited because about two third of the assigned energy requirement is calculated with a very accurate process analysis.
2. The energy analysis for cut flowers performed in this article is based on figures for flowers grown in the Netherlands by modern and well-managed companies in 1991. The average energy requirement for cut flowers in 1991 will probably be higher, up to 20% higher (Ruis, 1998) than calculated here. But differences for flowers in 1998 will be less, due to improved efficiency of the production sector. In four years time (between 1990 and 1994), a higher energy efficiency of greenhouse horticulture resulted in an energy requirement decrease of about 5% (Farla and Blok, 1997).
3. The energy required for cut flowers is based on such things as the direct energy required to light and heat the greenhouse in the 4-week period in which the flowers are purchased and the 8 preceding weeks. To check the influence of these 8 extra weeks, we varied this period from 4 to 12 weeks for the calculation of the energy required for a rose. The influence of the exact length of the period is relative small (Vringer and Blok, 1995a).
4. According to Vermeulen (1995) it is not profitable for growers to grow only flowers in summertime, which makes it unrealistic to differentiate the energy required for flowers per season. However, it is technically possible to grow flowers only in warmer periods. The energy required to keep the greenhouse frost-free in wintertime (necessary for some flowers like roses) is negligible in comparison with keeping the greenhouse at the proper growing temperature (Vermeulen, 1995).

Regarding the uncertainties of the reduction options, we have the following comments:

5. We assumed that households only select from the 15 best selling flowers. Real household consumption patterns include many more flowers, which can increase

the possibilities of some energy reduction options such as opting for other species and extending the lifetime of flowers. However, we do not expect that this has a significant impact on energy reduction potential. This is because these 15 sorts of flowers account for about 70% of the auction sales and the unweighted average energy required for the 15 best selling flowers does not differ much from the other 17 flowers analysed in the appendix.

6. The calculated total energy reduction potential includes the purchase of more imported flowers from warmer countries. Unfortunately, florists generally do not know the origin of the flowers they sell, which makes this choice only possible for consumers when flowers are labelled.
7. In this article, the achievable energy reduction potential for all options is roughly estimated. But some field data was available to evaluate the total energy reduction potential estimated here. This data comes from a project called “Perspective”. In this project, 10 to 15 households had to reduce their total energy requirement substantially for a longer period of time. Based on CEA (1998) figures, we calculated that these households managed to reduce their energy requirement for flowers with about 80%. CEA (1998) does not expect that long-term feasibility will be reduced. However, it should be noted that expenditures on alternative products for replacing cut flowers is not given in the CEA analysis and that it is not likely that the number of the functional units purchased is kept on the same level.

Final comments:

8. Extra time expenditures for households, which applies to (all) energy reduction options, is expected, but it is difficult to estimate how much due to lack of data. Especially extra investments of time are expected when the alternatives are first applied.
9. The extent to what cut flowers are environment-friendly cannot be expressed solely in the total energy required for cut flowers. The quantity and kind of insecticides, weed killers and land used are also important factors in the total environmental impact of cut flowers.
10. A change in the production process which leads to a (substantial) reduction of the energy required for flowers can have an affect on the effects of the consumer options discussed here. A study by Schoonderbeek et al. (1996) suggests that specific energy consumption by greenhouse horticulture may decrease by 80%. It is clear that if such a technical change should materialise, it would drastically alter the outcomes of our calculations.

Conclusions

Cut flowers are responsible for about 1% of total primary household energy requirements, in 1990 about 2.2 GJ per household). In 1990, an average Dutch household paid for Dfl.170 ($ 102) about 11 times one or more bouquets containing a total of about 250 cut flowers with an energy intensity of 13 MJ/Dfl (about 22 MJ/$), which is relative high. It is important to recognise that the energy required per flower depends on the type of flower and season of purchase.

We have examined various ways of reducing the energy requirement of cut flowers without loosing their function as household decoration. Some options that at present have high potential are replacement of flowers as a gift by other presents, making more use of flowering indoor plants and selecting less energy-intensive flowers (from abroad, other species, other seasons). A preliminary analysis in this article suggests that if all the consumer energy reduction options discussed here are applied to a substantial extent, the cumulative energy requirement for flowers of Dutch households can be halved.

The findings in this article can certainly not be extrapolated to other consumption categories, be if only because of the extremely high energy intensity of cut flowers. However, this analysis shows that there may be a variety of options that together have substantial potential for reducing the primary energy requirement. This variety seems to make achieving this potential a hard task. Further research in this area seems necessary before a affective policy directed at changing consumption patterns can be developed.

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Appendix

In this appendix, the calculated energy requirement per flower and the energy intensities are given for 13 4-week periods. Period 1 corresponds with January and period 13 with December.

Table A1 contains the energy required by 37 flowers for 13 4-week periods in MJ/each. Table A2 contains the energy intensities of 30 flowers (excluding the bulbous flowers) in MJ/Dfl. for all 13 4-week periods. All figures are up to the time the flowers are harvested.

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Table A1 Energy requirement of the commonly grown flowers per 4-week period in which they are harvested (in MJ per each).

Name	Common name	Period												
		1	2	3	4	5	6	7	8	9	10	11	12	13
ACTONIUM NAPELLUS (average)	Monkshood					21	17	2	2					
ACTONIUM NAPELLUS (greenhouse)	Monkshood					21	17							
ACTONIUM NAPELLUS (outdoors)	Monkshood							2	2					
ALCHEMILLA (outdoors)	Alchemilla						1							
ALSTROMERIA (greenhouse)	Peruvian Lily	76	91	37	14	9	9	9	8	9	9	9	11	19
ANEMONE (greenhouse)	Windflower	11	8	5	6	5			7	5	4	6	8	9
ANTHURIUM (greenhouse)	Flamingo flower	86	115	195	102	52	29	23	22	23	26	34	49	58
ANTIRRHINUM MAJUS (greenhouse)	Snapdragon				16	11						6		
ASTER ERICOIDES (greenhouse)	Michaelmas daisy				15	13	11	10	10	10	10	10	13	14
ASTILBE (outdoors)	False goat’s beard								2					
BOUVARDIA SINGLE (greenhouse)	Bouvardia	23	24	21	12	9	7	6	6	5	6	7	10	18
BOUVARDIA DOUBLE (greenhouse)	Bouvardia	39	41	22	14	11	8	7	6	6	7	8	11	22
BOUVARDIA SINGLE+DOUBLE (greenhouse)	Bouvardia	31	32	22	13	10	8	7	6	6	6	7	11	20
CALLICARPA (outdoors, unheated greenhouse)	Callicarpa											6	6	
CARTHAMUS TINCTORIUS (outdoors)	Chartamus								1					
CHRYSANTHEMUM (average)	Chrysanthemum	26	23	19	15	13	11	9	9	7	7	8	13	16
CHRYSANTHEMUM (greenhouse)	Chrysanthemum	26	23	19	15	13	11	9	9	9	8	10	13	16
CHRYSANTHEMUM (outdoors)	Chrysanthemum									3	3	3		
DIANTHUS, Large (greenhouse)	Carnation	53	56	41	19	6	4	4	3	4	4	6	10	34
DIANTHUS, Bunch (average)	Carnation	44	44	29	20	5	4	4	3	3	3	4	6	31
DIANTHUS, Bunch (greenhouse)	Carnation	44	44	29	20	5	4	4	3	3	4	5	9	31
DIANTHUS, Bunch (outdoors)	Carnation									3	3	3	3	
DIANTHUS BARBATUS (greenhouse)	Sweet William					8								
DIANTHUS BARBATUS (outdoors)	Sweet William							1						
DRIED FLOWERS (outdoors)									6					
ERYNGIUM PLANUM (outdoors)	Sea holly								2					
EUPHORBIA FULGENS (greenhouse)	Sun spurge													19
FORSYTHIA (average)	Forsythia	6	4	4										6
FREESIA (greenhouse)	Freesia	11	13	9	7	5	4	4	4	3	4	4	7	9
GERBERA (greenhouse)	Transvaal daisy	41	32	15	10	18	9	8	6	9	8	10	16	25

Table A1 (continued) Energy requirement of the commonly grown flowers per 4-week period in which they are harvested (in MJ per each).

Name	**Common name**	**Period**												
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
GYPSOPHILIA (average)	Baby’s breath				29	10	9	9	3	3	6	8	12	29
GYPSOPHILIA (greenhouse)	Baby’s breath				29	10	9	9			7	8	12	29
GYPSOPHILIA (outdoors)	Baby’s breath								3	3	3			
HIPPEASTRUM (greenhouse)	Amaryllis	12	14									10	15	11
LIATRIS (greenhouse)	Button snakeroot						11					9		
LIMOMIUM SINATUM (average)	Sea lavender				16	10	9	14	2	4	5	6		
LIMOMIUM SINATUM (greenhouse)	Sea lavender				16	10	9	14		6	5	6		
LIMOMIUM SINATUM (outdoors)	Sea lavender								2	2				
MATTHIOLA (greenhouse)	Stock				13		7							
PHLOX (outdoors)	Phlox							2	2	2				
PRUNUS (greenhouse)	Flowering cherry	5	6	6										
ROSA Small/average (greenhouse)	Rose (Motrea, Frisco, Mercedes)	15	15	12	11	8	7	6	6	6	6	7	9	11
ROSA Large (greenhouse)	Rose (Madelon)	27	26	22	19	15	12	10	9	9	10	12	16	21
ROSA (average, greenhouse)	Rose	18	18	15	13	10	8	7	6	6	7	8	11	14
SOLIDAGO (outdoors)	Golden rod								1					
TRACHELIUM (greenhouse)	Blue throatwort				23	22	9	8						
VIBURNUM (greenhouse)	Snowball	22	20	22	24	25								
TULIPA	Tulip	4	4	4	4	3	3	3	3	3	3	3	4	4
HYACINTHUS	Hyacinth	4	4	4	4	3	3	3	3	3	3	3	4	4
IRIS	Iris	5	5	5	5	4	4	4	4	4	4	4	5	5
LILIUM	Lily	13	14	13	11	8	6	6	6	6	6	8	10	12
NARCISSUS	Daffodil	4	4	4	4	3	3	3	3	3	3	3	4	4
GLADIOLUS	Sword lily	3	3	3	3	3	3	3	3	3	3	3	3	3
CROCUS	Crocus	3	3	3	3	3	3	3	3	3	3	3	3	3

Table A2 Energy intensity of the commonly grown flowers per 4-week period in which they are harvested (in MJ/Dfl.).

Name	Common name	PERIOD												
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
ACTONIUM NAPELLUS (average)	Monkshood					11	16	3	3					
ACTONIUM NAPELLUS (greenhouse)	Monkshood					11	16							
ACTONIUM NAPELLUS (outdoors)	Monkshood							3	3					
ALCHEMILLA (outdoors)	Alchemilla						3							
ALSTROMERIA (greenhouse)	Peruvian Lily	62	64	26	15	14	16	19	14	11	8	10	13	24
ANEMONE (greenhouse)	Windflower	16	15	12	11	17			59	22	10	10	10	11
ANTHURIUM (greenhouse)	Flamingo flower	26	29	44	26	17	16	13	10	8	9	9	17	12
ANTIRRHINUM MAJUS (greenhouse)	Snapdragon				14	17						12		
ASTER ERICOIDES (greenhouse)	Michaelmas daisy				17	15	12	14	15	11	10	12	13	18
ASTILBE (outdoors)	False goat’s beard								3					
BOUVARDIA SINGLE (greenhouse)	Bouvardia	45	47	36	21	16	14	16	16	11	10	11	15	28
BOUVARDIA DOUBLE (greenhouse)	Bouvardia	67	73	36	21	17	13	14	16	11	9	11	16	36
BOUVARDIA SINGLE+DOUBLE (greenhouse)	Bouvardia	56	60	36	21	17	13	15	16	11	10	11	16	32
CALLICARPA (outdoors, unheated greenhouse)	Callicarpa											3	3	
CARTHAMUS TINCTORIUS (outdoors)	Chartamus								5					
CRYSANTHEMUM (average)	Chrysanthemum	15	16	18	18	14	14	17	16	9	11	11	16	19
CRYSANTHEMUM (greenhouse)	Chrysanthemum	15	16	18	18	14	14	17	16	12	14	13	16	19
CRYSANTHEMUM (outdoors)	Chrysanthemum									3	3	2		
DIANTHUS, Large (greenhouse)	Carnation	71	82	80	30	8	7	7	7	6	6	8	16	46
DIANTHUS, Bunch (average)	Carnation	106	97	84	43	10	7	7	7	8	7	7	13	46
DIANTHUS, Bunch (greenhouse)	Carnation	106	97	84	43	10	7	7	7	8	8	10	20	84
DIANTHUS, Bunch (outdoors)	Carnation									7	6	5	6	
DIANTHUS BARBATUS (greenhouse)	Sweet William					18								
DIANTHUS BARBATUS (outdoors)	Sweet William							3						
DRIED FLOWERS (outdoors)									4					
ERYNGIUM PLANUM (outdoors)	Sea holly								3					
EUPHORBIA FULGENS (greenhouse)	Sun spurge													16
FORSYTHIA (average)	Forsythia	6	6	5										5
FREESIA (greenhouse)	Freesia	21	25	19	16	12	12	11	11	10	8	9	13	17
GERBERA (greenhouse)	Transvaal daisy	25	27	38	27	39	20	15	14	14	11	12	17	18
GYPSOPHILIA (average)	Baby’s breath				18	10	13	17	6	5	6	8	12	30

Table A2 (continued) Energy intensity of the commonly grown flowers per 4-week period in which they are harvested (in MJ/Dfl.).

Name	**Common name**	**PERIOD**												
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
GYPSOPHILIA (greenhouse)	Baby's breath				18	10	13	17			7	8	12	30
GYPSOPHILIA (outdoors)	Baby's breath								6	5	4			
HIPPEASTRUM (greenhouse)	Amaryllis	19	26									14	17	12
LIATRIS (greenhouse)	Button snakeroot					19						24		
LIMOMIUM SINATUM (average)	Sea lavender				25	10	13	24	5	9	8	11		
LIMOMIUM SINATUM (greenhouse)	Sea lavender				25	10	13	24		14	8	11		
LIMOMIUM SINATUM (outdoors)	Sea lavender								5	4				
MATTHIOLA (greenhouse)	Stock				14		15							
PHLOX (outdoors)	Phlox							4	5	5				
PRUNUS (greenhouse)	Flowering cherry	6	7	8										
ROSA Small/average (greenhouse)	Rose (Motrea, Frisco, Mercedes)	18	16	21	19	14	15	17	17	14	13	12	15	18
ROSA Large (greenhouse)	Rose (Madelon)	21	17	21	23	16	16	19	19	13	12	13	16	17
ROSA (average)	Rose	19	16	21	20	14	15	18	18	14	13	12	15	18
SOLIDAGO (outdoors)	Golden rod								5					
TRACHELIUM (greenhouse)	Blue throatwort				19	20	10	15						
VIBURNUM (greenhouse)	Snowball	5	6	6	7	13								