Chapter 3

The energy requirement of cut flowers and consumer options to reduce it[1]

► Abstract

Like all consumer products, cut flowers require energy during their life cycle. The aim of this chapter is to examine how households can reduce their primary energy requirement for the decorative and gift functions provided so far by cut flowers without reducing their consumption level, also taking into account the financial cost. In 1990, an average Dutch household purchased one or more bouquets 11 times during the year, coming to a total of about 250 flowers for Dfl. 170[2] (ca. EUR 77), requiring a total of 2.2 GJ or 1% of the total primary household energy requirement. The energy put into flowers (energy intensity) is among the highest of all non-energy household purchases, costing an average of 12.9 MJ/Dfl. Knowing the high energy requirement of cut flowers should motivate us to take a closer look at less energy-intensive alternatives; for example, replacing flowers as gift with other gifts, making more use of flowering indoor plants and selecting flowers that are less energy-intensive in their production and distribution (e.g. flowers of 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.

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1 This study reported here represents a slightly adapted version of Vringer, K. and Blok, K. ‘The energy requirement of cut flowers and consumer options to reduce it’, *Resources, conservation and recycling* 28 (2000): 3-28.

2 All monetary quantities are expressed in Dutch guilders (Dfl., 1990). One Dfl. = approximately 0.45 Euro or 0.6 US$ (1995).

1 ► Introduction

The energy required for production and distribution of consumer products during the life cycle of the product generally leads to CO_2 emissions. According to Vringer and Blok (1995a) about half the primary energy requirement of Dutch households is related to energy carriers like electricity, petrol and natural gas (direct energy requirement)[3]. The other half is embodied in the products and services consumed (indirect energy requirement). These products and services have different energy intensities[4]. Replacing products and services by less energy-intensive products and services can reduce the total primary household energy requirement and the concomitant CO_2 emissions. In this chapter we will explore the possibilities of such replacements by focusing on cut flowers.

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 for cut 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, namely, 22, 49 and 59 MJ/Dfl., respectively (Vringer and Blok, 1995a). The generally high energy intensity of cut flowers and indoor plants is all the more reason for taking a closer look at less energy-intensive alternatives. In this chapter we will focus only on cut flowers.

Cut flowers in this thesis will be seen as a decorative element in households and as items to give as gifts. The aim of this chapter is to examine the extent to which households can reduce their energy requirement by using alternatives to cut flowers in these functions. We will discuss the role of cut flowers and indoor plants in the framework of total sources for household decoration. This will be followed by the determination of the energy required for cut flowers in terms of type and season of

3 To calculate primary energy we applied average factors to transform primary energy requirement into final energy requirement for the Netherlands, as described by Van Engelenburg et al. (1994).

4 Energy intensity (expressed as MJ/Dfl.) is the total primary energy requirement divided by the consumer price.

purchase. Finally, we will discuss the household function of cut flowers and then proceed to discuss and quantify energy reduction options for cut flowers as a household decoration and gifts.

2 ► The role of cut flowers and indoor plants in household decoration

Many activities are carried out in households, decorating is being one of them. This activity consists of all actions, deliberations and decisions needed to decorate the house (Groot-Marcus et al., 1996) and requires several resources, including time and money[5]. Let us look at the energy requirement in terms of household time and money. The resources described here for household decoration include all time and money needed to furnish the house and garden. The energy requirement figures will apply then to furniture, upholstery, shopping and transport (this is to obtain the relevant products), housecleaning, waste disposal and wall decoration. Resources for heating and lighting the house are excluded. Financial expenditure (S) for the relevant consumption categories (*i*) was derived from the 1990 Household expenditure survey (CBS, 1992) and time expenditure from the 1990 Dutch time expenditure survey (TBO, 1990). The total household energy requirement (E) was calculated according to equation (1). Energy intensities (ε) are from Vringer and Blok (1995a).

$$\mathrm{E} = \Sigma(S_i * \varepsilon_i) \qquad (1)$$

The time, money and calculated energy requirements for household decoration in the Netherlands in 1990 are given in Table 3-1[6]. Expenditures for the consumption categories of transport (shopping), water (cleaning), domestic services (cleaning) and direct energy requirements (cleaning), given by CBS (1992) and TBO (1990),

5 Groot-Marcus et al. (1996) mentioned more household resources, such as 'goods facilities' (in this chapter: vases, pots, plant food & potting compost), 'space' (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 chapter.

6 The time expenditure in Table 3-1 is valid for persons above 12 years of age. The average household has 2.2 household members above 12 (CBS, 1992). To calculate the average time expenditure per household, time expenditures in Table 3-1 will have to be multiplied by 2.2.

relate to the portion attributed to the activity of household decoration. Expenditures for these partial attribution categories come to Dfl. 380 and an energy requirement of 4 GJ.

Table 3-1 Time, money and energy requirements for average Dutch household decoration in 1990.

	Financial expenditure (Dfl. per household)	**Time expenditure** (minutes per person per week)	**Energy intensity** (MJ/Dfl.)	**Energy requirement** (GJ per household)
Garden	241	47	8.3	2.0
Flowers and plants	279	17	15.6	4.4
Furniture	1334	-	4.0	5.3
Upholstery	79	-	4.6	0.4
Cleaning	349	150	9.1	3.2
Shopping	58	30	7.2	0.4
Other	252	32	5.4	1.4
Total	**2592**	**276**	**6.6**	**17.1**
Percentage of total	**6%**	**3%**		**7%**

Table 3-1 shows that household decoration in 1990 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. 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.

3 ▶ The energy requirement of cut flowers

We calculated the cumulative primary 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 taken from IKC-GenB (1991), where cost calculations for many types of cut flowers were divided into the required expenditures for decontamination, herbicides, water, packaging, transport to the auction, interest, depreciation and auction. The expected selling price, number of cut flowers produced[7] and natural gas and electricity requirements (for heating the glasshouse and assimilation lighting) were given for 13 periods of four weeks throughout the year.

Table 3-2 Calculated energy intensities for cost items of cut flowers 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.
Cold storage	10.0	MJ/Dfl.
Packaging	11.5	MJ/Dfl.
Auction	2.2	MJ/Dfl.
Interest	0.2	MJ/Dfl.

Energy intensities for all cost items are needed to calculate the energy requirements for flowers. These energy intensities are calculated with the EAP computer programme (Wilting et al., 1999), which is based on hybrid energy analysis[8] as described by Van Engelenburg et al. (1994). EAP also contains all additional necessary input-output data. Table 3-2 shows the calculated energy intensities for all cost items used for the energy analysis for cut flowers.

7 In this chapter, one stalk is equal to one flower. Some types of flowers have more than one flower on a stalk.

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

To calculate the energy requirements for flowers, expenditures according to IKC-GenB (1991) are multiplied by the energy intensities in Table 3-2 and the energy requirements for retailing and transport finally added. The retailing of flowers and plants accounts for 3.8 MJ per Dutch guilder added value, and cut flowers are sold for an average of 165% of the purchase price (Wilting et al., 1999). The energy requirement per flower can be calculated using this information.

To factor-in the influence of the season in which the flowers are purchased, we added the energy requirement to heat and light the glasshouse in the 4-week period to that of the two 4-week periods preceding the purchase of flowers, dividing the result by three. The eight extra weeks are taken into account, because flowers usually need about eight weeks to grow (Vermeulen, 1995).

Seven of the 37 cut flowers analysed were bulbous flowers such as tulips, hyacinths and lilies. IKC-GenB (1991) gives no extended figures for bulbous flowers, but Elderman et al. (1994) mention the total amount of natural gas required for cultivating a certain amount of several types of bulbs. The amount of natural gas needed for cultivation in Elderman et al. (1994) was distributed over 13 periods of four weeks, as in IKC-GenB (1991) for the other cut flowers described. If the time a bulbous flower needs to grow is taken into account, the energy requirement attributed to heating will be based on average energy requirements in the relevant period and the preceding 4-week period. We also assumed that all other steps in the production and distribution process of bulbous flowers would require 3 MJ of primary energy per flower, being equal to the average energy required by cut flowers grown out in the open. We also assume that cultivating one bulb would result in one flower.

Figure 3-1 shows the variation in energy required per month for six of the cut flowers most often sold. Appendix 3A contains the season-dependent energy requirements and energy intensities for all flowers analysed in all 13 periods of four weeks over the year.

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 glasshouse, but glasshouse flowers are available the whole year round. The energy intensity of some flowers like bouvardia, Peruvian lily and carnation in the wintertime is higher than the energy intensity of natural gas[9]. In wintertime, flowers such as the carnation require, per single flower, an amount of primary energy equal to 1 − 1.5 litre of petrol[10].

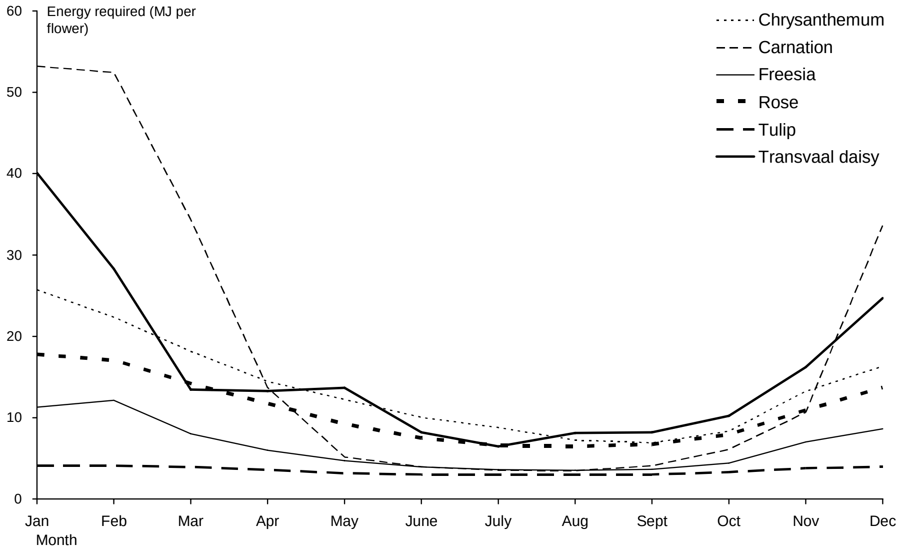

Figure 3-1 The seasonal variation in the primary energy required for six of the most sold cut flowers.

Most Dutch auction sales are destined for export[11]. However, according to CBS (1994) auction sales accurately represent the composition of flower types purchased by Dutch consumers as in Ten Hag and Van der Ham (1996). Using auction sales of

9 The energy intensity of natural gas as sold to households is about 60 MJ/Dfl. (Vringer and Blok, 1995). The energy intensity for these flowers may be higher because natural gas prices for glasshouse horticulture is much lower than that for households.

10 One litre of petrol requires 35 MJ (Wilting et al., 1995).

11 Seventy per cent of the cut flower production in the Netherlands in 1990 was for export and in the same year the Netherlands was responsible for nearly 60% of the total export of flowers worldwide (Hack and Heybroek, 1992).

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 (see Table 3-3).

Table 3-3 Auction sales measured as percentage of flowers sold, consumer price, energy requirement per flower and energy intensity for the 15 most auctioned types of flowers.

Type of flower	**Auctio sales** (flowers sold in %)	**Consumer price** (Dfl. per flower)	**Energy requirement** (MJ per flower)	**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
Total auction sales (weighted average)		**0.7**	**8.8**	**12.9**

Table 3-3 shows the average energy requirement per flower to be about 9 MJ and the average energy intensity at about 13 MJ/Dfl. An average household in 1990 spent Dfl. 280 on flowers and indoor plants (CBS, 1992). About 60% of this 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 one or more bouquets was/were purchased 11 times, coming to a total of about 250 flowers (Bertens et al., 1997). Assuming that the average energy requirement of all the flowers is the same for the 15 sellers, the total energy requirement will come to

2.2 GJ. Collectively, chrysanthemums and roses are responsible for half of all the flowers purchased and 60% of the average household energy requirement for cut flowers.

Figure 3-2 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 in the analysis. Compared to the information in Figure 3-1, the seasonal effect of the energy requirement is reduced because flowers exhibiting high energy consumption are sold mainly in the summertime and vice versa. Furthermore, the energy intensity in the summertime is not much lower than in the wintertime because of the lower summertime prices.

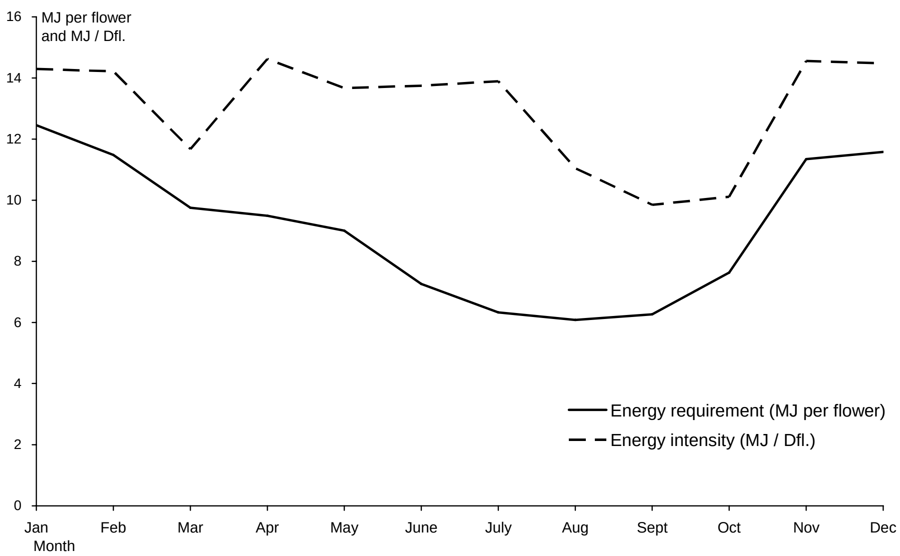

Figure 3-2 Average energy requirement and energy intensity for the 15 most commonly grown flowers in the Netherlands.

4 ► 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 can distinguish two functions for cut flowers: 1) as decorative element in the home and 2) as gifts.

Ultimately, cut flowers are (finally) used in most cases to decorate the house. But, flowers are not suitable for every kind of household decoration. Cut flowers often decorate a table, but indoor plants are more frequently chosen to decorate window sills (van Tilburg, 1984).

The most popular gift in the Netherlands is flowers (Komter and Schuyt, 1993; van der Velden, 1996). Flowers represent about 30% of the smaller gifts given[12] (van der Velden, 1996). About 50% of all the flowers purchased in 1995 were for gifts; the average price was 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 flower purchases were unplanned, while 75% of the households who planned to buy flowers had no specific type of flowers in mind before the actual purchase (van Tilburg, 1984). No relationship was found between the type of house (flat/apartment or detached house with a garden) and expenditures on flowers and indoor plants (CBS, 1996). However, there is a relationship between household expenditures on cut flowers and indoor plants and the 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). Nevertheless, the range in flower expenditures within the same income category is broad.

12 Up to Dfl. 30

5 ► Reduction options

Here, consumer energy reduction options will be discussed for cut flowers as household decoration and gifts consisting of cut flowers. Since all the options can nowadays be applied by households themselves, we have excluded energy reduction options that can be carried out by others, e.g. growers and retailers. If the energy reduction options described are applied, the total number of functional units will, as far as possible, be kept the same. A functional unit is defined as one gift or one decorative item, in most cases comparable to one bouquet of flowers.

First, the maximum annual energy reduction per option was calculated for an average Dutch household and, if relevant, also the impact on expenditures. Constraints of the reduction options will be subjectively discussed below.

We divided the energy reduction options into two main groups:

- Replacement by other kinds of product within the same product category
- Replacement by other products having a comparable function

These two groups of options and the maximum energy reduction will be discussed below. See Table 3-6 for an overview of all the options discussed, including additional constraints.

5.1 ► Replacement by other products in the same product category

There are a number of ways for households to reduce the energy requirement for cut flowers without replacing them with other kinds of decorative items, for example:

1. Buy more cut flowers in the summertime and fewer in the wintertime.
2. Buy less energy-intensive cut flowers.
3. Extend the lifetime of cut flowers by looking after them.
4. Buy cut flowers grown using environment-friendly methods.
5. Buy cut flowers grown in warm countries, instead of Dutch cut flowers.
6. Buy bulbs instead of bulbous cut flowers.

5.1.1 ► Buy more cut flowers in the summertime and fewer in the wintertime

A shift in season purchased can reduce the energy requirement of flowers. By buying some of the flowers (see Figure 3-2) in summertime[13] instead of wintertime, the energy requirement for cut flowers may be decreased by 20%[14]. 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) (ten Hag and 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 per year.

5.1.2 ► Buy less energy-intensive cut flowers

A shift to less energy-intensive flowers can, for some households, reduce the total energy required for flowers. Table 3-3 shows the average energy requirement per flower to be 8.8 MJ, varying from 3 to 51 MJ. The four flowers with the highest energy requirement per flower are chrysanthemums, Transvaal daisies, Peruvian lilies and Flamingo flowers all require more than 11 MJ per flower. About 66 of these four types of flowers are purchased per Dutch household per year. If chrysanthemums are replaced by Michaelmas daisies, Transvaal daisies by carnations, Peruvian lilies by lilies and flamingo flowers by amaryllis, the average energy required per flower decreases by 30%. We assume that this measure is only applicable to 85% of the four flowers with the highest energy requirement per flower, bought by households that do not always have flowers at home[15]. 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%

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

14 Average energy requirement per flower for the whole year is 9 MJ; average energy in summertime is 7 MJ per flower. About 46% of all flowers are sold in wintertime.

15 A household has to make 3.4 flower purchases per month in order to renew a bouquet of cut flowers immediately after an average and optimal lifetime of 8.9 days (see Table 3-4). 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 for decoration. So it can be assumed that about 15% of all cut flowers purchased are immediately replaced when they die.

(231 MJ) per year for an average household. The expenditures will remain unchanged.

Table 3-4 Lifetime under optimal conditions and the energy requirement.

Type of flower	Lifetime (days)	Energy requirement (MJ/flower)	Energy requirement per day (MJ/flower/day)
Peruvian lily	8.5	15.0	1.8
Flamingo flower	17.5	51.6	2.9
Michaelmas 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**

Households which always have flowers, can reduce their energy requirements by buying cut flowers with a longer lifetime. Table 3-4 shows the lifetime of the 15 best-selling species under optimal conditions, along with the calculated energy required per flower per day. Assuming that the flowers receive optimal treatment, without using plant food for cut flowers, the average energy required per flower per day is about 1.1 MJ. We assume less energy-intensive flowers to replace the four flower types 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 applicable to 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 unchanged, with the lifetimes of the three types of replacement flowers taken into account. The total effect of this option for all flowers purchased is a reduction of 12% (268 MJ).

5.1.3 ► Extend the lifetime of cut flowers by proper treatment

Proper treatment such as the use of clean vases and water, fertiliser and avoidance of direct sunlight, etc.) extends the lifetime of cut flowers substantially. Adding fertiliser extends the lifetime of Michaelmas daisies, carnations (small), freesias and roses by about 30%. Collectively, these four types account for 44% of all the flower-days[16] (see Table 3-4). Extending the lifetime by fertilising is less advantageous for other flowers (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 Michaelmas daisies, carnations (small), freesias and roses. Taking into account that this option only applies to 15% of all purchased flowers that are replaced immediately at the end of their lifetime, we find that the average energy requirement of cut flowers decreases by 2% (41 MJ per year per average household), while expenditures decrease by Dfl.3. The lifetimes of the three types of replacement flowers have been taken into account. We assume the extra costs and energy requirement for the extra fertiliser to be negligible.

5.1.4 ► Buy cut flowers grown using environment-friendly methods

Environment-friendly growers in the Netherlands try to reduce the energy required for growing their cut flowers. However, there are no unambiguous standards for the energy required for these flowers; nor are there signs that these flowers are grown more efficiently (Franke, 1995; Sperling, 1995).

Environmental-friendly flowers have been experimentally launched on the Dutch market and cost between 10% and 30% more than the cut flowers grown using

16 A flower-day relates to the presence of one cut flower in the house for one day. The lifetime of a small rose is 8.5 days (see Table 3-5), so ten small roses are good for 85 flower-days.

regular methods (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.

5.1.5 ► 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 the relatively warm climates of these countries. 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 per flower). This relatively slight 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 in Israel and 75% lower in Spain and Morocco (Verhaegh, 1996). Figures for other types of flowers are unavailable (van der Velden, 1998).

Flowers from Kenya are generally not grown in heated glasshouses (Kortlandt, 1998). According to Lenggenhager (1997)[17], the total energy requirement of Kenyan roses is about 2 to 3 MJ per rose, including transport. This energy requirement is 85% less than for Dutch roses. We assume the prices of imported flowers to be comparable with flowers grown in the Netherlands. Van Vliet (1998) and Van der Velden (1998) expect the energy requirement for Kenyan flowers to rise due to advances in flower cultivation. A reduction in the required energy by at least 10%, and maybe up to 85%, by buying flowers from warm countries seems feasible. The energy required for air transport of flowers is relatively insignificant (1 to 3 MJ per flower).

5.1.6 ► Buy bulbs instead of bulbous cut flowers

Buying bulbs instead of bulbous cut flowers saves the energy required for cultivating the bulbs. The energy required to cultivate one bulb is about 1 MJ, except

17 For the calculation, we used figures for the same type of rose (First Red) from the appendix in Lenggenhager (1997). We also included the energy needed for the production of electricity (total 10.3 MJ/kWh; see Table 3-2).

for lilies, which is 6 MJ per bulb. The total average energy required for bulbous flowers is 3 to 4 MJ per flower, except for lilies, at 9 MJ per flower. The energy reduction, which can be achieved by buying bulbs instead of bulbous flowers, is about 10% per bulb and about 60% for lilies[18]. Total energy reduction amounts to 80 MJ, or about 4% of the total energy required for all cut flowers purchased per average Dutch household, while a reduction in expenditures is not expected. We ignored the effect of a possible extension of the lifetime.

5.2 ► Replacement by other products with a comparable function

Households can reduce the energy requirement for cut flowers by replacing flowers with alternative decorations, such as:

1. indoor plants instead of cut flowers,
2. plastic/textile flowers instead of cut flowers,
3. paintings and sculptures, and
4. alternative gifts.

5.2.1 ► Buy indoor plants instead of cut flowers

Indoor plants have a much longer lifetime than cut flowers. Replacing relatively short-lived cut flowers with indoor plants can result in a reduction in energy requirement. The average number of cut flowers in the house, including flowers as gifts, is about six per day or, on average, about half a bouquet at a time. This means that all cut flowers in a household can, on average, be replaced by one indoor plant. If we assume the average flowering time of the flowering indoor plant (replacing the cut flowers) to be twice in three weeks, about eight plants per year are needed to replace all the cut flowers, including flowers given as gifts.

18 We added the extra energy required for the pot, in which usually multiple 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).

We assume that the energy required for one flowering plant is equal to that of a 60 cm *Ficus Benjamina*[19], i.e., 50 MJ each (Potting et al., 1995). The replacement of all flowers by indoor plants, excluding flowers purchased as a gift, saves 0.9 GJ per year, 41% of the annual energy requirement for cut flowers per average Dutch household. The energy intensity of indoor plants is almost the same as that of cut flowers (Potting et al., 1995), which means that financial expenditures decrease by 41%.

5.2.2 ► 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 amounting to 0.5 kg nylon with a lifetime of 10 years, costing Dfl. 10 each. The energy required for these 10 high-quality imitation flowers is calculated at about 500 MJ (calculated with Wilting et al., 1999). The reduction of the required energy is then about 48% (excluding flowers purchased for gifts) and can save Dfl.75 per year.

5.2.3 ► Buy paintings and sculptures instead of cut flowers

Decorations of art such as paintings and sculptures can replace a bouquet of flowers. If all flowers are replaced by art that costs the same and the lifetime of this art is 20 years, it will cost a household Dfl.2080[20]. We assume that the energy intensity of an art object as being equal to 1 MJ/Dfl. If all flowers are replaced by art, excluding flowers purchased for gifts, the annual net energy reduction will be about 48% of the total energy requirement for cut flowers.

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19 We chose *Ficus Benjamina* because it is one of the most often sold larger indoor plants at the auction (CBS, 1994).

20 Net current value of the annual expenditure of Dfl.170 for 20 years, including an inflation rate of 3% per year and 8% interest.

5.2.4 ► Buy alternative gifts

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

Table 3-5 Top 10 gifts most commonly purchased (Komter and Schuyt, 1993) and their respective energy intensities (Vringer and Blok, 1995a).

	Gift	Energy intensity (MJ/Dfl.)
0	Flowers	12.9
1	Food (chocolates, 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

6 ► Energy reduction options surveyed

Table 3-6 summarises the maximum achievable reduction of energy requirement for the options discussed. But every energy reduction option has constraints because of the limited consumer acceptability of the various options: alternatives may differ in their functionality. Data on these constraints is unavailable. On the basis of expected willingness of consumers, we have made the following rough assumptions of the effect of constraints:

- In lengthening the lifetime of flowers by adding fertiliser and a shift to less energy-intensive flowers, we assume an achievable reduction of 75% of the maximum. Most consumers decide the type of flowers they will buy at the place of purchase (van Tilburg, 1984). Only when the consumer buys and puts the flowers in a vase, some extra effort is required.

- Fifty per cent is assumed to be really achievable for the maximum achievable shift from bulbous flowers to bulbs and from cut flowers as gifts to alternative gifts. These options induce a change of product, which may require greater effort from the consumers and may be less acceptable due to changes in functionality.
- Twenty-five per cent is assumed to be really achievable for the maximum achievable shift in the purchase season from wintertime to summertime and from cut flowers to indoor plants. These options show a larger shift in decorative functionality than the previous solution and may be less acceptable.
- Only 5% is assumed to be achievable for the maximum achievable shift from cut flowers to artificial flowers, and from cut flowers to paintings and sculptures. It is very plausible that the artificial aspects of the plastic or textile flowers are unacceptable to many people. Art is also 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%.

When all constraints are included, the total energy reduction per average household will be about 1 GJ per average household if all options are applied. This is about half the annual energy required for cut flowers. About Dfl.25 will be saved. If this Dfl.25 is spent on average goods[21], the energy reduction will be about 0.1 GJ smaller. Figure 3-3 shows the part of the total current flower sales affected by the options and the achievable reduction of energy requirement, including all constraints and excluding the interactions between the options.

Again it should be emphasised that there is no data 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.

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

Table 3-6 Overview and effects of the options to reduce the energy requirement and expenditures of an average Dutch household, with achievable reductions, established subjectively.

Option	Maximum effect on the requirement for cut flowers (Percentage)	(MJ/year)	Maximum eff. on expenditures (Dfl./year)	Estimated potential due to constraints	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	
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 e.g. paintings and sculptures	-48 %	-1047	0	5 %	-2	0
Do not buy flowers for a gift but alternative gifts	-39 %	-860	0	50 %	-430	0
Total, corrected for overlapping of effects from individual measures****					-1067	-25

* For these options, we took into account the unsuitability of replacing flowers bought as a gift.
** The total is corrected for overlap by assuming that the first option in the table is carried out first, followed by the second and so on. The additional saving of each following option is calculated by applying the percentage of each saving on the resulting energy requirement after applying the options, which were already taken into account beforehand.
# We took an average of 30% for further calculations.

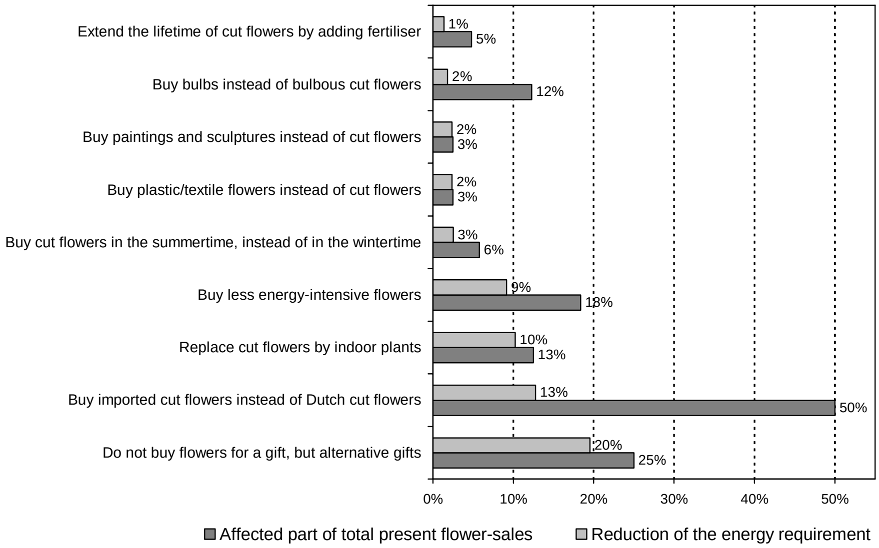

Figure 3-3 The part of the total current flower sales affected by the options and the achievable reduction of the energy requirement, including all constraints and excluding the interactions between the options.

7 ► Discussion

First, we will discuss the uncertainties in calculating the energy required for cut flowers. This will be followed by a discussion on the uncertainties of the reduction options and completed with a few additional comments.

Calculation of the primary energy required has raised several comments on uncertainty:

1. The energy required for cut flowers in this study was partly calculated through an input-output energy analysis, a less accurate method than process analysis; this is because energy is assigned on a financial and not on a physical basis. However, the possibility for error is limited because about two-thirds of the assigned energy requirement is calculated using a very accurate process analysis.

2. The energy analysis for cut flowers performed here on the basis of 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%) than calculated here (Ruis, 1998). But differences for flowers in 1999 will be less due to improved efficiency in the production sector. In four years time (between 1990 and 1994), a higher energy efficiency of glasshouse horticulture resulted in a decrease in the energy requirement of about 5% (Farla and Blok, 1997).

3. The energy required for cut flowers is based on such aspects as the direct energy required to light and heat the glasshouse 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 on the results is relatively small (Vringer and Blok, 1995b).

4. According to Vermeulen (1995) it is not profitable for growers to grow only flowers in the 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 glasshouse frost-free in wintertime (necessary for some flowers like roses) is negligible in comparison with keeping the glasshouse at the proper growing temperature.

Calculation of the reduction options has raised several more comments on uncertainty:

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 possibility of some energy reduction options such as opting for other species and extending the lifetime of flowers. However, we do not expect that this will have a significant impact on energy reduction potential. This is because these 15 types of flowers account for about 70% of the auction sales. Furthermore, the unweighted average energy required for the 15 best-selling flowers does not differ much from the other 17 flowers analysed in Appendix 3A.

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. This chapter offers rough estimates of the achievable energy reduction potential for all options. However, some field data were available to evaluate the total energy reduction potential estimated here. These data come from a project called ‘Perspective’, in which 10 to 15 households had to substantially reduce their total energy requirement for a longer period of time. On the basis of data in CEA (1998) we calculated that these households managed to reduce their energy requirement for flowers by about 80%. CEA does not expect long-term feasibility to 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 will be maintained on the same level.

Final comments:

8. Although extra time expenditures for households − applying to (all) energy reduction options − is expected, it is difficult to estimate how much time is needed due to lack of data. Especially extra time investments are expected when the alternatives are first applied. The effect of extra time expenditure on the total energy requirement can be positive (no other activities are possible during the extra time expenditure) or negative (lack of time leads to use of time-saving options, e.g. taking the car instead of public transport).

9. The extent to which cut flowers are environment-friendly cannot be expressed solely in the total energy requirement for cut flowers. The quantity and kind of insecticides, weed killers and soil surface used are also important factors in the total environmental impact of cut flowers. To give an overview of all environmental aspects, a complete Life Cycle Assessment (LCA) would have to be carried out per type of flower.

10. A change in the production process which leads to a (substantial) reduction in the energy required for flowers can have an impact on the effects of the consumer options discussed here. A study by Schoonderbeek et al. (1996) suggests that specific energy consumption by glasshouse horticulture may decrease by 80%. It is clear then that if such a technical change should materialise, it would drastically alter the outcomes of our calculations.

11. Dutch households spend, relatively speaking, twice as much money on flowers as households in several other European countries (Eurostat, 1988). This means that the energy savings for Dutch households presented here will be typically twice as much as energy savings for households in other European countries.

12. The worldwide average energy requirement per flower is possibly lower than for flowers produced in the Netherlands. Roses grown in warmer countries like Morocco, Israel, Spain and Kenya are produced with less energy (10 to 85%). However, in 1990, nearly 60% of all exported flowers worldwide were produced in the Netherlands (Hack and Heybroek, 1992). Therefore the results of the energy analysis presented in this chapter can be applied to more than half of all the flower exports worldwide.

8 ► Conclusions

Cut flowers are responsible for about 1% of the total primary household energy requirements; in 1990 this was about 2.2 GJ per household. In 1990, an average Dutch household paid Dfl.170 (US$ 102) for a total of 250 cut flowers (one or more bouquets purchased 11 times a year) with an energy intensity of 13 MJ/Dfl. (about 29 MJ/€ or 22 MJ/US$), which is relatively high. It is important to recognise that the energy required per flower depends on the type of flower and season of purchase.

In this chapter we have examined various ways of reducing the energy requirement of cut flowers without the household decoration being affected. Some options with a current high potential are replacing flowers as a gift; here more use is made of flowering indoor plants and less energy-intensive flowers (from abroad, other species and other seasons) are selected. A preliminary analysis in this chapter 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 chapter can certainly not be extrapolated to other consumption categories, be it only because of the extremely high energy intensity of cut flowers. However, this analysis does show that there may be a variety of options with a substantial collective potential for reducing the primary energy requirement. This variety seems to make achieving this potential a difficult task. Further research in this area is necessary before an effective policy directed at changing consumption patterns can be developed.

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Appendix 3A

This appendix shows the calculated primary energy requirement per flower and the energy intensities for 13 4-week periods. Period 1 corresponds with January and period 13 with December.

Table 3A-1 contains the energy required by 37 flowers for 13 4-week periods in MJ per flower. Table 3A-2 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.

Table 3A-1 Energy requirement of the commonly grown flowers per 4-week period in which they are harvested (MJ per flower).

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 (glasshouse)	Monkshood					21	17							
ACTONIUM NAPELLUS (outdoors)	Monkshood							2	2					
ALCHEMILLA (outdoors)	Alchemilla						1							
ALSTROMERIA (glasshouse)	Peruvian Lily	76	91	37	14	9	9	9	8	9	9	9	11	19
ANEMONE (glasshouse)	Windflower	11	8	5	6	5			7	5	4	6	8	9
ANTHURIUM (glasshouse)	Flamingo flower	86	115	195	102	52	29	23	22	23	26	34	49	58
ANTIRRHINUM MAJUS (glasshouse)	Snapdragon				16	11						6		
ASTER ERICOIDES (glasshouse)	Michaelmas daisy				15	13	11	10	10	10	10	10	13	14
ASTILBE (outdoors)	False goat's beard								2					

Table 3A-1 Energy requirement of the commonly grown flowers per 4-week period in which they are harvested (MJ per flower). (Cont.)

Name	Common name	Period												
		1	2	3	4	5	6	7	8	9	10	11	12	13
BOUVARDIA SINGLE (glasshouse)	Bouvardia	23	24	21	12	9	7	6	6	5	6	7	10	18
BOUVARDIA DOUBLE (glasshouse)	Bouvardia	39	41	22	14	11	8	7	6	6	7	8	11	22
BOUVARDIA SINGLE+DOUBLE (glasshouse)	Bouvardia	31	32	22	13	10	8	7	6	6	6	7	11	20
CALLICARPA (outdoors, unheated glasshouse)	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 (glasshouse)	Chrysanthemum	26	23	19	15	13	11	9	9	9	8	10	13	16
CHRYSANTHEMUM (outdoors)	Chrysanthemum									3	3	3		
DIANTHUS, Large (glasshouse)	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 (glasshouse)	Carnation	44	44	29	20	5	4	4	3	3	4	5	9	31
DIANTHUS, Bunch (outdoors)	Carnation									3	3	3	3	
DIANTHUS BARBATUS (glasshouse)	Sweet William					8								
DIANTHUS BARBATUS (outdoors)	Sweet William							1						
DRIED FLOWERS (outdoors)									6					
ERYNGIUM PLANUM (outdoors)	Sea holly								2					
EUPHORBIA FULGENS (glasshouse)	Sun spurge													19
FORSYTHIA (average)	Forsythia	6	4	4										6
FREESIA (glasshouse)	Freesia	11	13	9	7	5	4	4	4	3	4	4	7	9
GERBERA (glasshouse)	Transvaal daisy	41	32	15	10	18	9	8	6	9	8	10	16	25
GYPSOPHILIA (average)	Baby's breath				29	10	9	9	3	3	6	8	12	29
GYPSOPHILIA (glasshouse)	Baby's breath				29	10	9	9			7	8	12	29
GYPSOPHILIA (outdoors)	Baby's breath								3	3	3			
HIPPEASTRUM (glasshouse)	Amaryllis	12	14									10	15	11
LIATRIS (glasshouse)	Button snakeroot						11					9		
LIMOMIUM SINATUM (average)	Sea lavender				16	10	9	14	2	4	5	6		

Table 3A-1 Energy requirement of the commonly grown flowers per 4-week period in which they are harvested (MJ per flower). (Cont.)

Name	Common name	Period												
		1	2	3	4	5	6	7	8	9	10	11	12	13
LIMOMIUM SINATUM (glasshouse)	Sea lavender				16	10	9	14		6	5	6		
LIMOMIUM SINATUM (outdoors)	Sea lavender								2	2				
MATTHIOLA (glasshouse)	Stock				13		7							
PHLOX (outdoors)	Phlox							2	2	2				
PRUNUS (glasshouse)	Flowering cherry	5	6	6										
ROSA Small/average (glasshouse)	Rose (Motrea, Frisco, Mercedes)	15	15	12	11	8	7	6	6	6	6	7	9	11
ROSA Large (glasshouse)	Rose (Madelon)	27	26	22	19	15	12	10	9	9	10	12	16	21
ROSA (average, glasshouse)	Rose	18	18	15	13	10	8	7	6	6	7	8	11	14
SOLIDAGO (outdoors)	Golden rod								1					
TRACHELIUM (glasshouse)	Blue throatwort				23	22	9	8						
VIBURNUM (glasshouse)	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 3A-2 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 (glasshouse)	Monkshood					11	16							
ACTONIUM NAPELLUS (outdoors)	Monkshood							3	3					
ALCHEMILLA (outdoors)	Alchemilla						3							
ALSTROMERIA (glasshouse)	Peruvian Lily	62	64	26	15	14	16	19	14	11	8	10	13	24
ANEMONE (glasshouse)	Windflower	16	15	12	11	17			59	22	10	10	10	11
ANTHURIUM (glasshouse)	Flamingo flower	26	29	44	26	17	16	13	10	8	9	9	17	12
ANTIRRHINUM MAJUS (glasshouse)	Snapdragon				14	17						12		
ASTER ERICOIDES (glasshouse)	Michaelmas daisy				17	15	12	14	15	11	10	12	13	18
ASTILBE (outdoors)	False goat's beard								3					
BOUVARDIA SINGLE (glasshouse)	Bouvardia	45	47	36	21	16	14	16	16	11	10	11	15	28
BOUVARDIA DOUBLE (glasshouse)	Bouvardia	67	73	36	21	17	13	14	16	11	9	11	16	36
BOUVARDIA SINGLE+DOUBLE (glasshouse)	Bouvardia	56	60	36	21	17	13	15	16	11	10	11	16	32
CALLICARPA (outdoors, unheated glasshouse)	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 (glasshouse)	Chrysanthemum	15	16	18	18	14	14	17	16	12	14	13	16	19
CRYSANTHEMUM (outdoors)	Chrysanthemum									3	3	2		
DIANTHUS, Large (glasshouse)	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 (glasshouse)	Carnation	106	97	84	43	10	7	7	7	8	8	10	20	84
DIANTHUS, Bunch (outdoors)	Carnation									7	6	5	6	
DIANTHUS BARBATUS (glasshouse)	Sweet William					18								
DIANTHUS BARBATUS (outdoors)	Sweet William							3						
DRIED FLOWERS (outdoors)									4					

Table 3A-2 Energy intensity of the commonly grown flowers per 4-week period in which they are harvested (in MJ/Dfl.). (Cont.)

Name	Common name	Period												
		1	2	3	4	5	6	7	8	9	10	11	12	13
ERYNGIUM PLANUM (outdoors)	Sea holly								3					
EUPHORBIA FULGENS (glasshouse)	Sun spurge													16
FORSYTHIA (average)	Forsythia	6	6	5										5
FREESIA (glasshouse)	Freesia	21	25	19	16	12	12	11	11	10	8	9	13	17
GERBERA (glasshouse)	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
GYPSOPHILIA (glasshouse)	Baby's breath				18	10	13	17			7	8	12	30
GYPSOPHILIA (outdoors)	Baby's breath								6	5	4			
HIPPEASTRUM (glasshouse)	Amaryllis	19	26									14	17	12
LIATRIS (glasshouse)	Button snakeroot					19						24		
LIMOMIUM SINATUM (average)	Sea lavender				25	10	13	24	5	9	8	11		
LIMOMIUM SINATUM (glasshouse)	Sea lavender				25	10	13	24		14	8	11		
LIMOMIUM SINATUM (outdoors)	Sea lavender								5	4				
MATTHIOLA (glasshouse)	Stock				14		15							
PHLOX (outdoors)	Phlox							4	5	5				
PRUNUS (glasshouse)	Flowering cherry	6	7	8										
ROSA Small/average (glasshouse)	Rose (Motrea, Frisco, Mercedes)	18	16	21	19	14	15	17	17	14	13	12	15	18
ROSA Large (glasshouse)	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 (glasshouse)	Blue throatwort				19	20	10	15						
VIBURNUM (glasshouse)	Snowball	5	6	6	7	13								