

When lighting consumption in the UK was assessed through detailed modelling, previous estimates were doubled (Palmer 1997, DECADE 1995). Actual measurements of lighting electricity use confirmed this revision (Electricity Association 1998), hence validating the modelling techniques used. This provides confidence in the revision to German household lighting consumption, giving a figure more than double prior estimates, through the use of the same modelling approach (Chapter 8).

Across the EU, the proportion of household electricity used for lighting varies from 7-27% between countries, depending on other electrical end-uses in the home, particularly heating. Within the home, lighting use is highest in the living room, accounting for around 40% of lighting consumption in Denmark and Greece. Comparing lighting electricity use by floor area implies that Finnish and Polish homes have the highest levels of lighting.



Figure 4-1 Average household lighting electricity consumption by country, Europe (kWh pa)

Even with reliable figures for lighting electricity use, variations between countries can be due to a variety of reasons. The number of bulbs, the wattage of these bulbs and their hours of usage are all factors which determine the level of consumption, although this is not a direct relationship. These variables are, in turn, influenced by a wide range of other factors such as the size of the house, number of people, household income, economics, aesthetics, country and culture. Trying to identify the key factors is difficult, although the number of people in the house has been found to be particularly important in Bulgaria (Yaneva and Welinov 1997) and the UK (Palmer 1997, Electricity Association 1998). Lighting electricity use has also been found to be strongly associated with income in the UK (Electricity Association 1998).

The trend towards increasing numbers of households, and particularly single person households, across the EU is likely to result in an increase in lighting electricity use.

4.2 OWNERSHIP

Across Europe, there is wide variation in the average number of light bulbs per household, ranging from 4 to 40, giving an EU average of 24. A high number of bulbs does not appear to be necessarily related to high levels of electricity use. However, it is difficult to establish if this is true, given the lack of confidence in some figures.

While data on the total number of light bulbs per household were available for the majority of countries, a more detailed split between the different bulbs in the house was more difficult to obtain. It is apparent that

incandescent GLS bulbs are still the dominant light source in all countries, representing at least 70% of the installed bulbs. The most commonly used wattage is 60W. Fluorescent tubes are usually found in the kitchen, with an average of one or two per household in most countries. Ownership of CFLs is covered in section 4.4.

Halogen bulbs, both low and high voltage, are becoming increasingly popular throughout Europe, typically used in the living room and kitchen. A substantial amount of research has been done on halogen torchieres in the Netherlands, where ownership of these fixtures has rapidly increased within a short space of time (Kavelaars 1997). The concern is that the use of these high wattage bulbs negates any savings achieved through the installation of CFLs. Halogen lighting is also common in France, Germany, Italy and Sweden.

As with the market data, information on fixtures was also difficult to obtain. There are differences across Europe in both the style and type of fixtures found in the home. There appears to be a current trend in some countries towards a 'Scandinavian way of lighting' - a high number of fixtures with low wattage bulbs.

4.3 ATTITUDES

Differences exist between countries in the way in which lighting in the home is perceived, with variations in the type of lighting that people want and the level of interest they actually take in how they light their homes. Such attitudes may be determined by a number of factors such as culture, climate and the history of lighting. Based on the comments provided for the country pictures, the following section gives an overview of people's views on lighting. Such a comparison is very general - there will, of course, be many variations within a country. There is a more detailed investigation into attitudes to lighting for Germany, Spain, Sweden and the UK in Chapter 7.

General interest in using light within the home to create atmosphere and ambience appears to be greater in Northern Europe, particularly among the Nordic countries. This is likely to be due to the long hours of darkness during the winter months and the colder climate - warm, cosy lighting, mimicking fire light, is popular. Since artificial lighting plays an important role in these people's lives it may also explain why they are more fashion conscious in terms of the lighting they install in their homes, using fixtures of modern designs. Attitudes among people in countries slightly further South, such as the Netherlands and the UK, appear to be changing, with increasing interest in the way they light their homes.

In Southern Europe, the need for artificial lighting is more constant across the year since there are not such extremes in daylight hours between winter and summer. Also, hours of actual sunlight will be higher and people typically spend more time outside rather than in the house. The fact that artificial lighting is not so central in people's lives is reflected in the apparent lack of interest that people take in lighting. They appear to be less concerned with the aesthetics of lighting, regarding it as something which is purely functional. In Portugal, for example, fixtures may not have a shade covering the bulb. Bright, white light is said to be preferred in Spain and Italy - creating a feeling of warmth is not so necessary in a warm climate.

The Eastern European countries are more limited by finances than tastes, although people are keen on modern technologies in Hungary and Poland. Modern European designed fixtures are expensive and are only found in higher income households in Lithuania.

Opinions on incandescent light sources are similar throughout Europe: GLS bulbs are viewed as low maintenance, cheap and easy to replace. Halogens have a modern image, producing aesthetically pleasing light which is described as interesting and exciting. Fluorescent lighting often has a slightly negative image being functional but of poor light quality, although opinions on CFLs vary (see section 4.4).

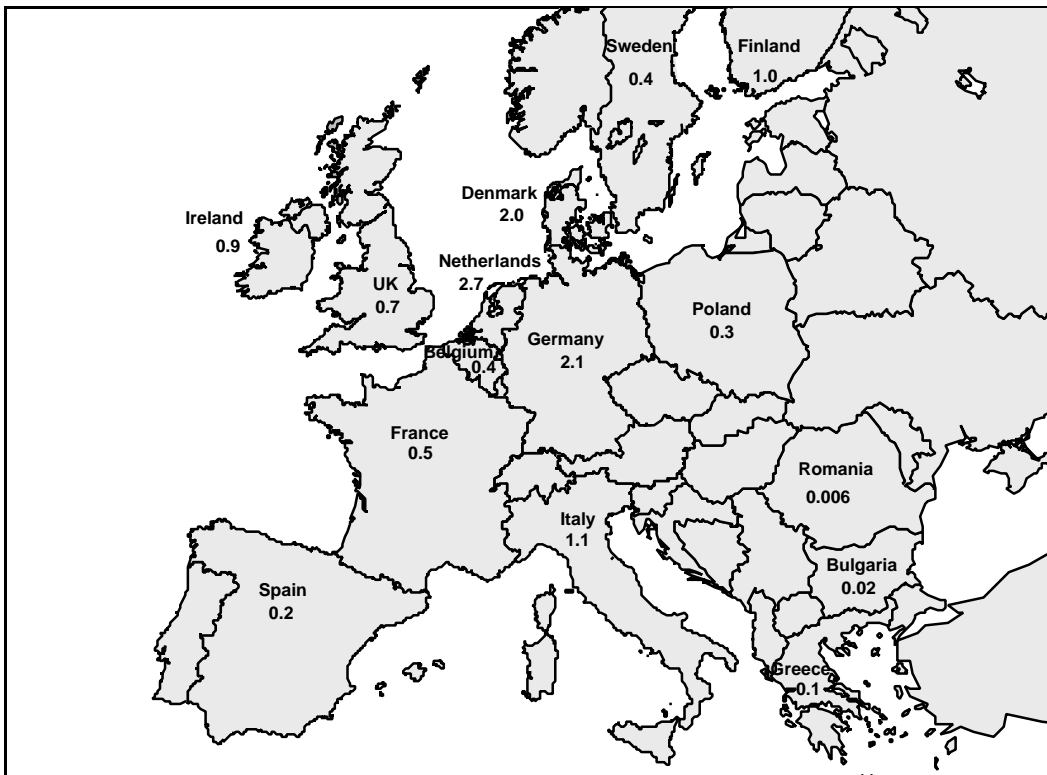
4.4 CFLs

4.4.1 CFL ownership

Data from the country profiles indicate that there are over 130 million CFLs installed in approximately 30% of households in the EU, giving an average of 1 CFL across all households. However, there is a wide range of ownership between different countries, the Netherlands having the highest ownership level: 62% of households owning an average of 4.5 CFLs. Despite this range, those EU households that own CFLs have an average of three or four. Whether this indicates the existence of a barrier to installing more CFLs at this level or whether it actually reflects the fact that ownership has built up slowly over time is unclear.

Ownership of CFLs in the Eastern European countries is slightly lower, as would be expected given the relatively high price of CFLs compared to the average household income. CFLs are also a more recent

introduction onto the market in these countries. The range of CFL ownership across Europe is shown in Figure 4-2.



Base: all households

Figure 4-2 Average number of CFLs per household by country, Europe

In general, ownership tends to be higher among larger (both in terms of size and number of people), higher income and educated households. The geographical concentration of high CFL ownership in the Netherlands, Germany and Denmark is likely to be related to the length of time the bulbs have been available on the market. The headquarters of Osram and Philips also happen to be located in Germany and the Netherlands. Countries with the highest ownership tend to have the lowest relative price of CFLs compared to incandescents (10 to 16 times as expensive). These countries have also had a large number of campaigns, which have resulted in increased demand, reducing the retail price of CFLs. This is in stark contrast to the Eastern European countries, where CFLs are up to 50 times more expensive than incandescents and can be as much as a quarter of the average monthly wage.

Living rooms, hallways, dining rooms and kitchens are common locations for CFLs in most countries, all being relatively high use locations. They are often used for external lighting in Denmark and Sweden. The most popular CFL appears to be 11W, with 9W also common. In the UK, electronic ballast CFLs are more popular than magnetic CFLs, with four times as many electronic CFLs installed in British homes (Rowe pers comm 1997). This trend away from magnetic ballast CFLs is likely to be reflected in the rest of the EU, particularly when the proposed EU directive to phase out low efficiency ballasts comes into force.

4.4.2 Attitudes to CFLs

Despite the fact that CFLs have been available for almost two decades, there is still a lack of awareness of this technology and the range of different types available throughout Europe. Awareness is lowest in the Eastern European countries, although CFLs are a more recent introduction there. People sometimes confuse CFLs with halogens or fluorescent tubes.

Price is often quoted as the major barrier for those people who have not yet bought a CFL. Those households that own a CFL are generally satisfied with them and price is less of an issue. The key motivations for installing a CFL vary between countries. In Denmark, Germany and the Netherlands, the environmental benefits are important, whereas in Spain this does not seem to be a crucial factor in encouraging CFL purchase. In Southern Europe, people are positive about the quality of light from a CFL, since it produces the bright clear light that they prefer and so they may require fewer incentives to use CFLs. In the Eastern

European countries, the cost savings are important. This is particularly because the price of electricity, which has been kept low in the past, is increasing, thus stimulating interest in energy saving measures.

The main benefits of CFLs are considered to be financial savings, long life, and therefore convenience. In Southern Europe the quality of light is also valued.

In the Northern countries, particularly Denmark, Finland, Germany and Sweden, the size and design of CFLs is unpopular. There are two reasons for this - the actual appearance of the bulb is felt to be unattractive and the shape and size of the CFL makes it incompatible with people's fixtures. This is more of an issue in these countries because of the popularity of small low wattage fixtures. Lack of suitable fixtures is often quoted as a barrier to installing CFLs, particularly in Germany and the Netherlands. This issue is investigated in the technical survey (Chapter 6).

4.5 CONCLUSIONS

There is a lack of reliable information on residential lighting for many European countries, making comparisons between countries difficult. Where better information has been obtained, this indicates where other, less robust, figures may need to be checked. Detailed research has resulted in estimates of lighting electricity consumption being increased in Germany and the UK, raising the importance of this area in terms of policy. Establishing a reliable baseline is an essential step towards accessing the savings achievable in this sector.

Residential lighting consumption in the fifteen EU countries is around 86 TWh, representing an expenditure of 10.3 billion ecu. Lighting electricity use varies with floor space and the number of people in the home, but there are insufficient data to confirm the relative importance of these factors or others, such as geography and household income. Interest in lighting in the home appears to be growing, accompanied by an increase in the numbers of bulbs used - halogens being particularly popular. However, there are still 70% of households in the EU without a CFL. Those households in the EU that do own CFLs usually have around three or four out of an average of 24 bulbs in total per household.

CHAPTER 5: THE THREE CASE STUDIES

Having set the scene for residential lighting in Europe, the report now focuses on the three DELight partner countries: Germany, Sweden and the UK. These countries represent a fair cross-section of Europe on the basis of a number of characteristics which relate to lighting, such as levels of electricity consumption, the structure of the Electricity Supply Industry and the type of lighting installed in the home. However, it is difficult to know the extent to which the countries are actually representative of lighting in Europe, since it is not clear what representative means for lighting. Some of the important characteristics are outlined here to give an indication of how applicable the in-depth studies of these three countries (covered in the next three chapters) are to the rest of Europe.

5.1 HOUSEHOLDS

There are around 64 million households in Germany, Sweden and the UK - representing just over 40% of all households in the EU. Dwellings range in size from an average of 110m² in Sweden, to 92m² in Germany with those in the UK being the smallest at 84m². The three countries are situated in the northern half of Europe, Sweden at the extreme with the longest hours of darkness during winter.

Electricity used in households in these three countries accounts for 45% of residential electricity consumption in the EU, with prices across the countries covering the full range found in the EU (Table 5-1).

Table 5-1 Total residential electricity consumption, Germany, Sweden and UK, 1995/6

	Residential Electricity Consumption (TWh)	Proportion of EU Residential Electricity Consumption	Price of residential electricity (ecu/kWh)
Germany	111.7	21.5%	0.16
Sweden	19.2	3.7%	0.08
UK	101.6	19.6%	0.10
EU	519.0	100%	0.08-0.17

Source: Country pictures (See Chapter 2 of supplementary report)

5.2 ELECTRICITY INDUSTRY

The structure of the Electricity Supply Industry (ESI) in each country is slightly different:

- Germany: The ESI has three levels : nine national utilities, responsible for the majority of electricity generation, 46 regional and about 800 local utilities. Each group accounts for around one third of electricity sales to households.
- Sweden: There are over 300 electricity suppliers in Sweden, with 90% of the total supply concentrated in the seven or eight largest companies.
- The UK: Great Britain has fourteen regional Public Electricity Suppliers, three main generating companies and an independent distribution network. Northern Ireland has a separate organisation. Liberalisation of the gas and electricity markets should be complete by the end of 1998 when each householder will be able to choose to purchase both gas and electricity from a wide range of companies.

The ESI structure and liberalisation of the industry are important factors in terms of motivation for investment in energy efficiency. The EC Directive adopted in 1996 has laid the foundation for liberalisation of the electricity market in all fifteen Member States, with the corresponding directive for the gas market expected to follow in 1998. Liberalisation of the UK ESI began in 1992 and has been used as a model of this process in other countries, such as Sweden where deregulation of the electricity market came into force on 1 January 1996. A major consequence of liberalisation is that introduction of energy efficiency through regulation of utilities is far more difficult. In the UK, the Energy Savings Trust (EST) was set up to perform this role in conjunction with the Office of Electricity Regulation (OFFER). The German ESI is currently in the process of liberalisation, representing a move away from the network of small, local government owned utilities which has encouraged a strong political interest in energy efficiency in the past.

The method of electricity generation also varies between the countries, as shown in Table 5-2. Germany and the UK are similar, with a large percentage of fossil fuel generation, reflected in the high CO₂ emission factors. The German and UK governments have committed to reducing CO₂ emissions by 25% and 20%

respectively from 1990 levels by 2010. In contrast, Sweden has a very low proportion of fossil fuel generation, the majority of electricity generated being hydro-electric and nuclear. The political focus in Sweden is to reduce dependence on nuclear power, rather than achieving reductions in CO₂ emissions.

Table 5-2 Electricity generation mix, Germany, Sweden and UK

	Fossil fuels	Nuclear	Hydro-electric	Renewable	Carbon dioxide emission factors 1997 (kg C/kWh)
Germany (1993)	66%	29%	3%	2%	0.20
Sweden (1997)	4%	48%	48%	-	0
UK (1995)	71%	27%	1%	1%	0.12

Sources:

Germany: Hessisches Ministerium fuer Umwelt, Energie und Bundesangelegenheiten 1994;

Sweden: EM 1998;

UK: DUKES 1996.

5.3 RESIDENTIAL LIGHTING

5.3.1 Electricity consumption

Average household lighting electricity use in all three countries is similar: 720 kWh per annum in the UK, 760 kWh pa in Sweden and the highest in Germany at 775 kWh pa, representing around 16% of residential electricity consumption in Sweden and the UK and 27% in Germany. These figures are taken from the results of the stock models of lighting consumption undertaken as part of this project (Chapter 8) and can therefore be considered to be reliable estimates. The UK is the only one of the three where actual monitoring of lighting consumption has been undertaken (Electricity Association 1998), confirming the figure of 720 kWh pa and therefore giving greater confidence in the figures. There is currently a study in Sweden measuring hours of lighting usage but the full results are not yet available and in Germany, no monitoring has been conducted to date.

As a proportion of residential peak demand, domestic lighting in the UK represents around 27% (Electricity Association 1998). Peak load for the whole system is around noon in Germany. There is a strong motivation in the UK to reduce residential lighting consumption in order to reduce peak load.

5.3.2 Ownership

German and Swedish households have a higher number of bulbs than the EU average of 24, with an average of 30 and 40 bulbs respectively. Ownership in the UK is lower at 20 bulbs per household. Halogen lighting is very popular in Germany and Sweden, but is not so widespread in the UK. In terms of CFL ownership, Germany has the highest percentage of households with CFLs as well as the highest number of CFLs per household and the cheapest bulbs. Sweden has the lowest level of ownership, although the average number of CFLs per owning household is similar to Germany (Table 5-3).

Table 5-3 CFL ownership and price, Germany, Sweden and UK

	Price of CFLs (ecu)	Percentage of households owning CFLs	Number of CFLs per owning household
Germany	10	50%	4.3
Sweden	13	10%	4.0
UK	15	23%	3.0

Source: Country pictures

The installation of light fixtures in the home and the extent to which they are perceived to be part of the house is different for each country. In the UK the majority of ceiling and wall fixtures are fixed and considered to be part of the house - when people move they will only take their portable fixtures with them. In Germany, the ceiling and wall fixtures are also fixed, but most are taken with people when they move house, along with the portable lights. Installation of fixtures in Sweden is quite different - most ceiling and wall fixtures plug into sockets provided on the walls and ceilings and so cannot be classified as fixed in the same way. The only locations where the fixtures may be wired into the house are the kitchen and bathroom. Apart from these, Swedish householders take all their light fixtures with them when they move.

The differences in the way fixtures are installed indicates the need for some policies to be country-specific. For instance, specifying energy efficient luminaires in the building regulations for new homes would be effective in the UK, but would have little effect in Sweden or Germany. It is not clear which, if any, of these systems represents what is typically found throughout Europe, but the UK appears to be unusual.

The various CFL campaigns that have been undertaken in each country are summarised in Chapter 9.

5.4 DETAILED STUDIES

Three key aspects of lighting were investigated in the detailed studies of the three countries:

1. An on-site survey to identify the type of lighting installed in homes and the extent to which this represents a barrier to installing energy efficient lighting.
2. A telephone survey to establish people's attitudes to CFLs and lighting in general and the resulting barriers that exist.
3. Construction of a lighting stock model estimating lighting electricity consumption and the potential savings available for each country.

The results from each are discussed in the following three chapters.

CHAPTER 6: TECHNICAL CONSTRAINTS

6.1 INTRODUCTION

The use of integral ballast CFLs, rather than modular or dedicated systems, is the most common application of CFLs in the domestic sector, treating them as direct replacements for GLS bulbs. While this approach has the advantage, in theory, of being the quickest way to access the savings and does not require any major changes to the fixtures in the home, it is not ideal. The majority of luminaires in homes across Europe are designed for, and use, GLS bulbs and are therefore not necessarily suitable for use with CFLs. Because of differences between the two technologies, there are a number of factors that need to be taken into account when using CFLs in the existing fixtures, such as orientation of the bulb and light distribution. Most householders will be unaware of these technical issues and, given the present retail structure and lack of informed retail staff, they are unlikely to find out about them. Mis-application of the technology, by using CFLs in inappropriate fixtures, may well have put people off using CFLs in the past because of the resulting poor light quality or shortened bulb life.

Aesthetics are also an important issue, and becoming more so, both in terms of the appearance of the bulb in the fixture and the suitability of the light output - CFLs are not appropriate in all locations, for instance where accent lighting is desired, which is better provided by halogens. Hence, the successful application of integral ballast CFLs is dependent on identifying the right type of CFL to use in a particular fixture, ensuring good performance of the bulb and satisfaction of the householder.

There is currently a wide range of different sizes and shapes of CFLs available on the market. While, on the one hand, this means it should be easier to find the right type of bulb to suit a certain fixture, it can also be confusing for the householder. Another consequence of the constant appearance of new products on the market is the lack of confidence this generates in the stability of the technology. If people are unsure of new technologies, they tend to keep to well-tryed solutions which have worked in the past, although these may not be ideal (Wood-Robinson 1983).

The lack of suitable fixtures is often quoted by householders as a reason for not installing integral ballast CFLs. The extent to which this is true, in terms of physical fit, aesthetics and bulb performance, was investigated through a detailed survey in the three partner countries. Suitability was judged from both a technical point of view, by a lighting expert, and from the householder's point of view, in terms of what they would be happy using in their home. The results from the survey indicate how far the existing luminaires actually represent a barrier to energy efficient lighting, as well as highlighting areas where fixture designs could be improved. Further details on the survey design and analysis of the results are included in Chapters 4 and 7 of the Supporting Material and in Palmer and Suvilehto (1997) and Persson (1997).

6.2 METHODOLOGY

On-site surveys were carried out in 24 households in each of the three countries during July and August 1997. Due to the in-depth nature of these surveys, it was not possible to use a larger sample. The households were selected by the surveyor in each country and located in Kiel (Germany), Halmstad (Sweden) and Gloucestershire (UK). The surveyors aimed to achieve a cross-section of households in terms of age (of the householders), accommodation type (flat or house) and location (rural, village and town). Even though this does not constitute a representative sample, the information collected provides a useful and informative starting point for looking at the role of the fixture in determining the potential for energy savings and also allows an initial comparison of this potential and of the lighting installed in the different countries.

The key pieces of information collected from each household were:

1. a detailed inventory of all luminaires in the house, both internal and external, classified by type of fixture, the bulb(s) it held and if it was the 'primary' fixture (ie the most used) for that particular room;
2. the suitability for CFLs of those fixtures designed for GLS bulbs in terms of what was acceptable to the surveyor (the 'technical potential') and to the householder (the 'acceptable potential'), independent of the surveyor's opinion;
3. the type of light the householders use for various tasks and the householders' attitudes to CFLs, based on questions taken from the cultural survey - another part of the DELight project (see Chapter 7).

Five categories were used to classify suitability of the luminaires for integral ballast CFLs:

1. **CFL will not physically fit:** the structure of the fixture would not allow replacement of the GLS bulb with a CFL (Figures 6-1 and 6-2). Installation of a CFL would require a new fixture.
2. **Unacceptable colour rendering:** the CFL fits into the fixture, but the colour rendering was inappropriate for the particular location of that luminaire. This could be corrected through a new fixture.
3. **Poor light distribution:** the CFL fits into the fixture, but the light distribution is unacceptable. Again, this could be corrected through a new shade or fixture.
4. **CFL protrudes from the shade:** the CFL fits into the fixture but is too long and protrudes from the shade (Figures 6-3 and 6-4). This could be corrected by a new shade.
5. **Successful conversion:** direct replacement with a CFL is possible with acceptable appearance, light distribution and quality (Figures 6-5 to 6-8).

There was also a further category of those luminaires which were not considered for conversion, classified as 'conversion not attempted'. This includes fixtures installed with fluorescent strips or tungsten halogen bulbs, any CFL dedicated fixtures and those fixtures on dimmer switches.

Because the surveys were carried out during the summer months, it was only possible to gauge opinion on the performance of the bulbs in daylight. Therefore, the issue of light quality could not be fully investigated in the survey. This is of more relevance to the acceptable potential, since the surveyors would have been aware of such issues when assessing suitability. Quality of light was investigated in more detail in the cultural survey (Chapter 7).

For simplicity, categories 1 to 4 have been amalgamated in the following analysis to give three main classes: 'successful conversion', 'for future conversion' (categories 1 to 4 combined) and 'conversion not attempted'.

6.3 KEY RESULTS

6.3.1 Type of lighting installed

Incandescent bulbs were the dominant light source in all the households surveyed, GLS bulbs being used in 79-81% of luminaires (Table 6-1). In the German and Swedish households, a greater proportion of luminaires were installed with halogen bulbs than with CFLs. Ownership of CFLs was highest in the UK sample: with those households that owned them having an average of three, consistent with the national picture. CFL ownership was lower than the national average in the Swedish and German samples, at two and three CFLs per owning household respectively. Multiple bulb luminaires were common in the German and Swedish households whereas in the UK, most luminaires were single bulb. The use of 'Christmas tree lights' (strings of twenty-five to forty 2W bulbs) in several of the German households means that the average number of light bulbs may be slightly high. Since it is not known what is representative, the extent to which these households reflect typical lighting in the three countries is unclear.

Table 6-1 Information on surveyed households: technical survey in Germany, Sweden and UK

		Germany	Sweden	UK
Household information	number of households	24	24	24
	number of rooms per household	3.8	3.9	4.5
Light bulbs	number per household	36	45	21
	average installed wattage (W)	1438	1539	1231
	average wattage per bulb	40	34	59
Light fixtures	average number per household	21	30	20
	% with incandescent bulbs	GLS	79	80
	tungsten halogen	8	6	5
% with fluorescent bulbs	fluorescent strips	7	11	3
	CFLs	6	3	11

Note:

Number of rooms excludes kitchens and bathrooms, but bulbs and fixtures in these rooms are included
 These figures are from the 72 households surveyed and may not be nationally representative

The UK households had the lowest number of bulbs with the highest average wattage per bulb, whereas Sweden had the highest number of bulbs but with the lowest average wattage. Dimmer switches were most popular in Swedish households, being used with 7% of luminaires compared to 4% in Germany and 5% in the UK. These represent a further barrier to CFLs at present. Differences in the style of lighting are also reflected in the range of fixtures found in the households (Table 6-2). The UK households have a high percentage of ceiling fixtures whereas the German and Swedish households have a greater proportion of wall and free-standing luminaires.

Table 6-2 Types of fixtures installed in the surveyed households: technical survey in Germany, Sweden and UK

	Germany	Sweden	UK
Ceiling pendant	15%	9%	37%
Ceiling surface/recessed	24%	22%	23%
Wall mounted	26%	28%	18%
Floor-standing	10%	5%	4%
Table and desk luminaire	21%	23%	18%
Other	4%	13%	0%

Base: 24 households in each country

In terms of fixed and portable fixtures, 78% of the UK luminaires were fixed, 65% in Germany and only around 11% in Sweden. It is important to note that fixed fixtures in the UK and Sweden are left behind when people move house, whereas almost all fixtures, both portable and fixed, move with the householder in Germany.

6.3.2 Potential for CFLs

The potential identified in this survey is in terms of the opportunities for installation of integral ballast CFLs into the existing fixtures in the home. A full list of the CFLs used in the surveys is included in Chapter 4 of the Supporting Material. Across the three countries, the surveyors found 32-42% of all luminaires suitable for CFLs, without any modification necessary (Table 6-3). The percentages appear lower for Sweden and Germany because of the high proportion of luminaires that were not considered for conversion, due to the popularity of halogen bulbs and dimmer switches in these households.

Table 6-3 Technical and acceptable potential for CFLs: technical survey in Germany, Sweden and UK

	Technical potential			Acceptable potential		
	Germany	Sweden	UK	Germany	Sweden	UK

Successful conversion	34%	32%	42%	32%	31%	46%
For future conversion	47%	43%	50%	49%	44%	46%
Conversion not attempted	19%	25%	8%	-	-	-

Base: 24 households in each country - percentages of all fixtures

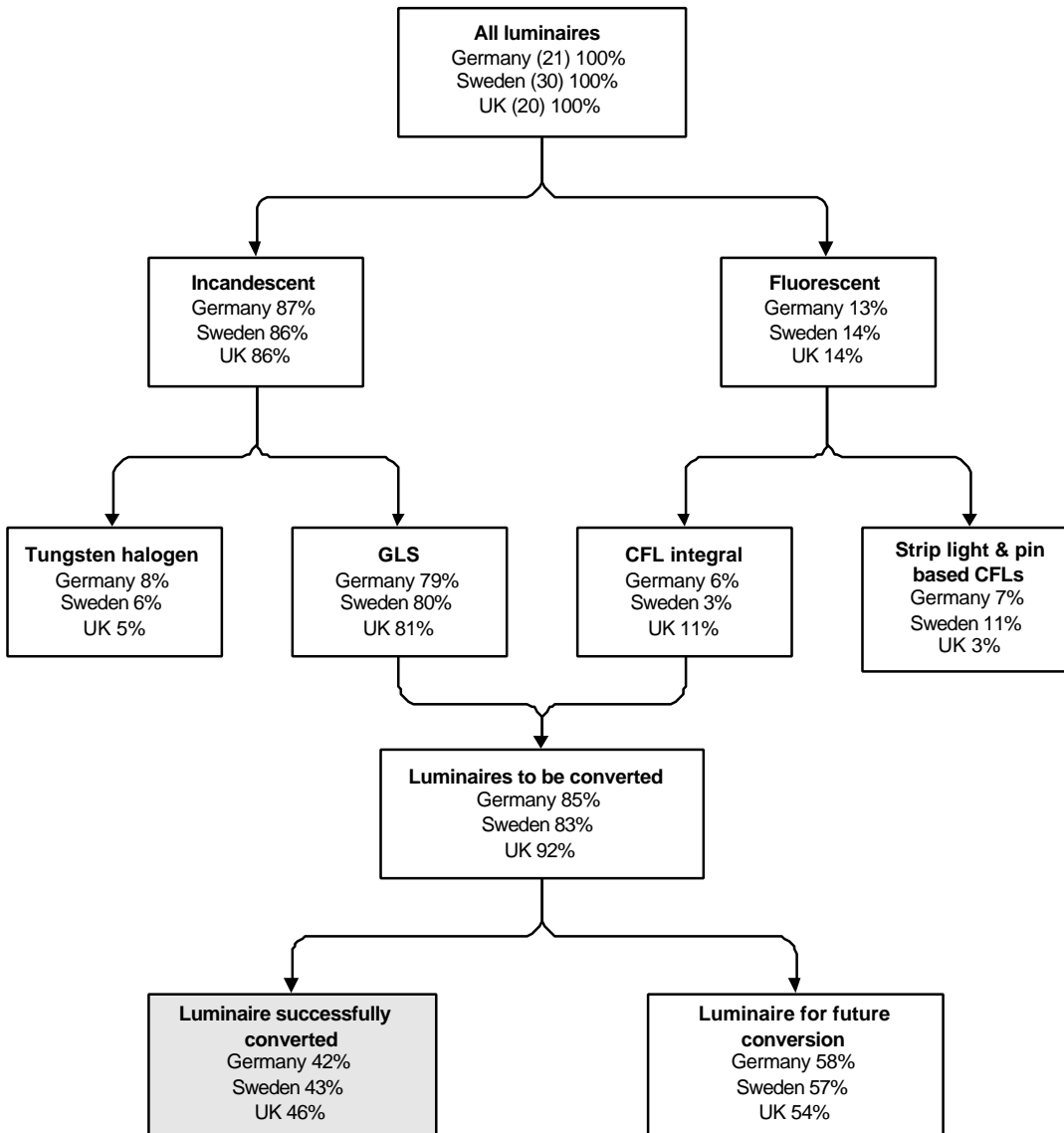
There is good agreement between the technical and acceptable potentials in all three countries, with the UK households apparently more willing to accept CFLs in fixtures considered unsuitable by the surveyor than in Germany and Sweden. Although the householders' opinions will have been influenced to a certain extent by taking part in the survey, the acceptable potential illustrates that it is possible to use CFLs in the existing fixtures to the satisfaction of the householder. This may not, of course, represent what they will actually do in practice. Many of the householders were surprised at the range of CFLs used in the survey, which was far greater than found in most retail outlets, and felt it to be confusing. However, they did have the opportunity to try out the various types in their own fixtures, making it easier to identify the right one to use. This highlights the benefit of expert advice and demonstrations in encouraging the appropriate use of CFLs.

Since the focus is on installing integral ballast CFLs in luminaires designed for GLS bulbs, it is useful to look at the 'technical potential' in terms of these fixtures (ie excluding those in the 'conversion not attempted' category). This gives a similar proportion of luminaires suitable for immediate conversion in each country, ranging from 42-46% (Figure 6-9).

Assuming one bulb per luminaire as a minimum, the 'successful conversion' category indicates that, in each household, at least seven bulbs in Germany, nine bulbs in Sweden and eight bulbs in the UK could be changed to CFLs immediately.

These potentials are conservative estimates. Given current trends towards smaller CFLs and CFLs made to look like traditional incandescent bulbs, the number of existing luminaires that could be considered to be successful conversions will increase in the future. Also, by simply replacing the shade, requiring minimal investment on the part of the householder, the 'successful conversion' category could be almost doubled in Germany and the UK.

However, the 'successful conversion' category will never reach 100% of luminaires since there will always be some fixtures where CFLs are not appropriate, either for technical, economic or aesthetic reasons. Such locations represent an opportunity for other energy-efficient light sources to replace GLS bulbs, such as the IEA 'future bulb'.



Note: These figures are from the 72 households surveyed and may not be nationally representative

Figure 6-9 Technical potential for installing CFLs into the existing fixtures: technical survey in Germany, Sweden and the UK

6.3.3 Fixture types suitable for conversion

Some luminaire types were more suited to the installation of CFLs than others. A breakdown of ‘successful conversion’ category in terms of the different fixture types is shown in Figure 6-10. This is helpful in guiding the householder to which fixtures are most appropriate for CFLs. Ceiling pendant fixtures were particularly suitable for conversion in the UK (Figures 6-5 and 6-6), while ceiling surface and recessed luminaires were more successful in Sweden. In luminaires where the bulb was visible, globe CFLs were effective and often represented an improvement on GLS bulbs because glare was reduced (Figure 6-7). Cooker hoods were identified as being good conversions for CFLs in terms of physical fit, but low levels of usage and high temperature may mean that such locations are unsuitable.

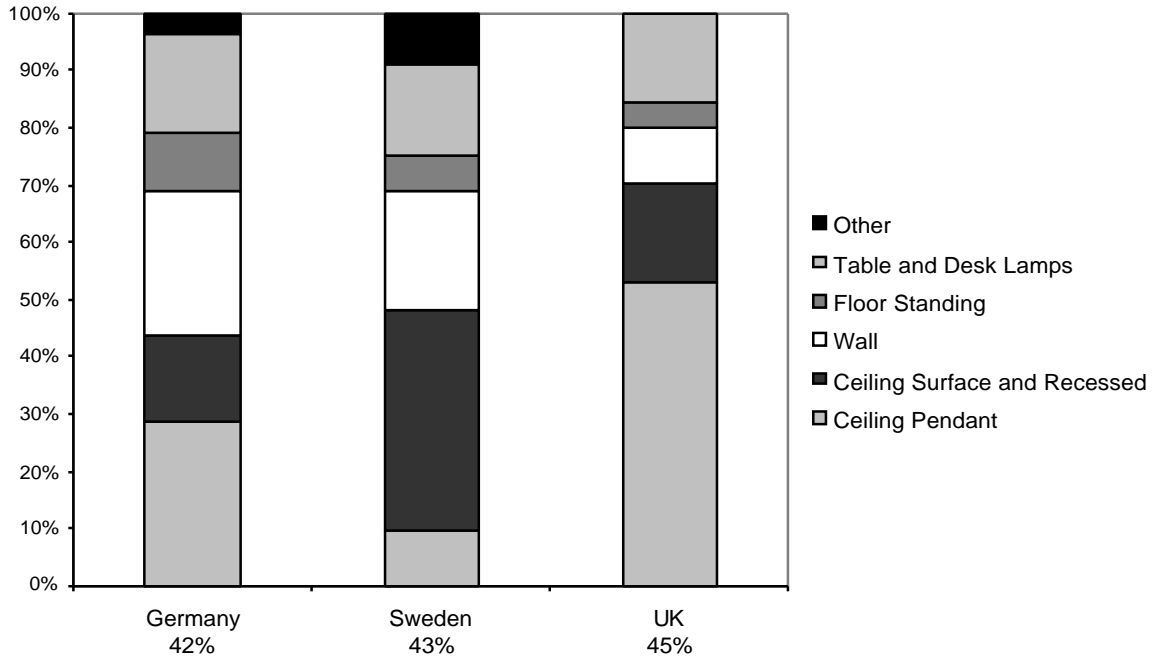


Figure 6-10 Proportion of fixture types within the successful conversion category: technical survey in Germany, Sweden and UK

The fixture types that were classified as being for future conversion represent an opportunity for appropriate dedicated fixture designs. As illustrated in Figure 6-11, the existing wall fixtures and table and desk lamps made up a large proportion of this category in all three countries.

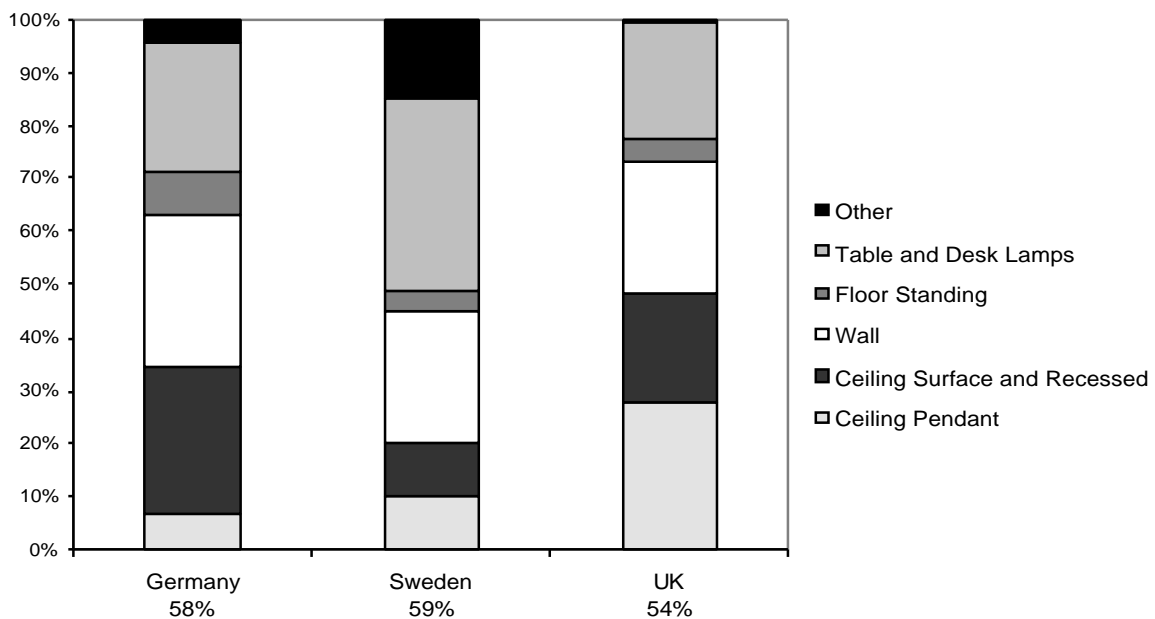


Figure 6-11 Proportion of fixture types considered unsuccessful conversions: technical survey in Germany, Sweden and UK

6.3.4 Cost-effectiveness of conversions

Not all the successful conversions identified offer a rapid pay back to the householder. Identification of the primary luminaire for each room gives an indication of relative usage levels and therefore the cost-effectiveness of these conversions. The actual hours of use of primary luminaires will vary depending on the

room they are in (for instance, the primary luminaire in the bedroom is likely to be used less than the one in the living room), and who within the household defined them. Of the luminaires in the ‘successful conversion’ category, 66% in Germany, 50% in Sweden and 74% in the UK were also classified as primary fixtures. Therefore, the majority of successful conversions are the most cost-effective for a particular room and offer the fastest pay back in high use locations such as living rooms and hallways.

A study by DEFU established that it was cost-effective to install eleven CFLs, on the basis that these bulbs were used for more than two hours a day, in households in Denmark, Germany and the Netherlands, (DEFU 1996). Six CFLs was assumed to be a more realistic estimate for immediate installation, since some of the eleven fixtures would need modification and the householder may not accept all of them. The results from the technical survey have confirmed that some of these could be installed immediately, given the constraints of the fixtures. However, a number of high use fixtures will require modification before the full savings estimated by DEFU can be achieved, since not all fixtures identified as suitable will be in use for over two hours a day.

6.3.5 Electricity savings

The electricity savings indicated by the potentials were calculated for the primary fixtures in the four highest used locations (for more details, see Chapter 7 of the Supporting Material). Usage figures were available from other studies conducted in Sweden and the UK: a Swedish project, run by the utilities of Borlänge and Upsalla, measuring hours of lighting use and a survey of householders’ estimates of lighting usage in the UK (Electricity Association pers comm 1997). No such data were available for Germany and so hours of usage were estimated by the surveyor. The following were identified as the highest used areas:

- halls, main living room, kitchens and external in Germany;
- halls, landing, main living room and external in Sweden;
- halls, landings, kitchens and main living room in the UK.

Installing one CFL in the primary fixtures in each of these four locations could achieve savings of around 200 kWh per household (Figure 6-12), assuming an average daily usage of 3.5 hours per bulb. This would be to the complete satisfaction of the householder, provide a good light (by professional standards) and require no expenditure on the fixture. It would, therefore, be at least the same level of service as the present bulbs. Because these are high use fixtures, the expenditure would be cost effective and the savings would repay the additional price of four or five bulbs in under three years.

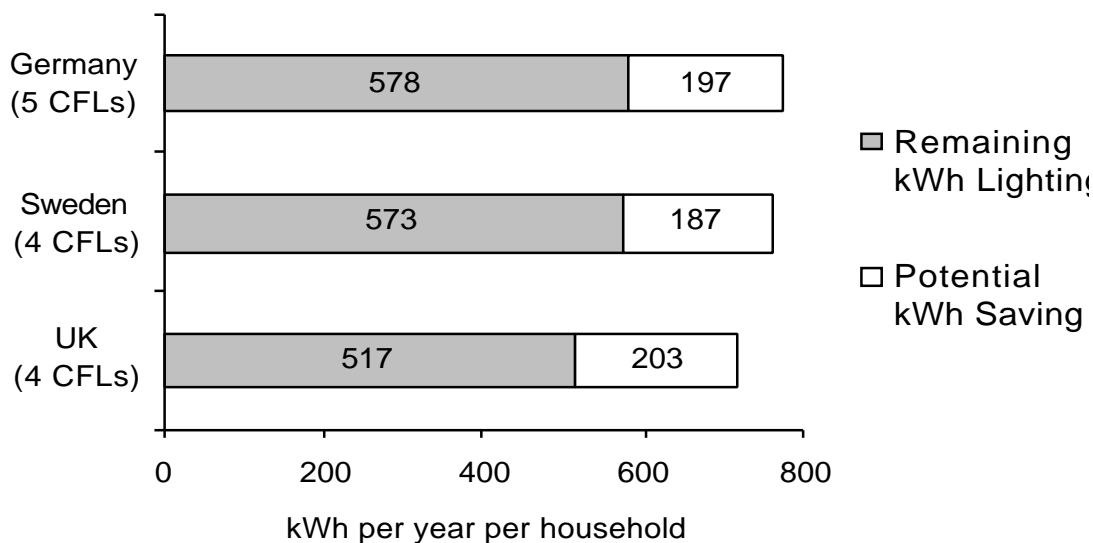


Figure 6-12 Electricity savings from installing CFLs in fixtures in the four highest used locations: technical survey in Germany, Sweden and UK

6.3.6 Location of CFLs in practice

Since a number of the surveyed households already used CFLs, it is possible to identify where they had installed these bulbs prior to taking part in the survey (Table 6-4). Across the three countries, the majority of these CFLs were installed in the high use locations. The living room was the most popular place for CFLs in

Germany and the UK, whereas they were more likely to be used in the kitchen or for external lighting in Sweden.

Table 6-4 Location of installed CFLs: technical survey in Germany, Sweden and UK

	Germany	Sweden	UK
Main living room	28%	9%	22%
External	17%	35%	9%
Kitchen	10%	30%	7%
Hall	10%	0%	16%
Total	65%	74%	54%

Base: CFL owners in each country

However, in Sweden, only 43% of these were primary fixtures, compared to 76% in Germany and 84% in the UK. This indicates that it may be more difficult for Swedish householders to install CFLs in locations which are most cost effective.

6.4 CONCLUSIONS

In the 72 houses surveyed, around 80% of fixtures currently use an incandescent bulb. There was a larger proportion of halogen bulbs installed compared to CFLs in both Germany and Sweden. This distribution of ownership is confirmed by national sales data used in the stock model of lighting electricity consumption (Chapter 8). There is greater similarity in the type of lighting installed in the German and Swedish homes than in the UK. The UK households are different in terms of both the number and type of bulbs installed as well as the style of fixtures and the way in which they are wired into the house. These households had a high proportion of fixed ceiling luminaires, with the majority of fixtures using a single high wattage bulb. Whilst this gives greater savings per bulb (for example, a 20W CFL replacing a 60W GLS bulb in the UK, compared with a 9W CFL replacing a 25W GLS bulb in Sweden), the use of multiple bulb luminaires in Germany and Sweden means relatively larger savings per fixture than in the UK.

In all three countries, the potential for the installation of integral ballast CFLs is similar at 42-46% of existing incandescent luminaires. This represents what could be done immediately and is acceptable to the householder, requiring no further investment other than the purchase of the bulb. The majority of these CFLs would go into the highest used fixture in a room. This is a conservative estimate given the possibilities of smaller CFLs in the future and the marginal cost of changing some shades. In order to achieve this potential, it is likely that people will need guidance on how to identify which of their fixtures are suitable and how to choose the appropriate type of CFL. There are also further savings available through the application of other technologies, such as the IEA 'future bulb', where the use of CFLs is inappropriate.

This approach provides an indicative national figure, irrespective of the bias in the small samples. The figure of 46% of incandescent fixtures in the home being suitable for CFLs can, therefore, be used with sufficient confidence. These results form the basis of the FITP (Fixtures and Immediate Technical Potential) scenario described in Chapter 8, illustrating the maximum level of savings the conversions could achieve when extrapolated to the whole country.

Since a large proportion of the existing fixtures are suitable for use with CFLs, there is no need to look at the economics of changing fixtures in the short-term. There are already ample, cost-effective opportunities available that are acceptable to the householder. The immediate savings of 200 kWh represent over a quarter of lighting electricity used of a typical household (720-775 kWh) in the three countries. In the longer term, the survey indicates the types of fixtures which are currently unsuitable for CFLs and may therefore be an appropriate target for any programme focusing on the design of CFL dedicated fixtures.

CHAPTER 7: CULTURAL ISSUES

The success of CFLs depends upon the technology satisfying the requirements people have for lighting in their homes. It is therefore important to establish what these requirements are. Lighting is not just something to see by - it is important in creating an atmosphere in the home. The type of light that people want in their hallway will be different to the lighting they may choose for the living room or the kitchen. Such requirements will also vary between countries; Wilhite *et al* (1995) demonstrated differences in attitudes to lighting between countries, with a corresponding impact on energy use. An understanding of how people's lighting requirements vary between rooms and between countries can help to identify suitable energy efficient lighting systems, using the appropriate combination of CFLs and fixtures.

People also have to believe that CFLs can satisfy their lighting requirements. Around 70% of households in the EU do not currently own a CFL. Price is frequently given as the main reason for this, although people are also unsure about the performance and light quality of the bulbs. However, many of these concerns are no longer justified with today's technology. Some of the misconceptions about CFLs have arisen because fluorescent lighting has (in Europe at least) associations with lighting in the workplace, and an image of giving a strong, harsh light. Bad experiences with CFLs in the past, either as a result of using the inferior early technologies, or because of the use of CFLs in inappropriate fixtures and locations, have also played a part in generating myths about CFLs. Such misconceptions seem to be preventing people from installing their first CFL. Once this first step has been taken, the average household goes on to buy another two or three CFLs, indicating that experiencing the technology can help overcome some of these misconceptions. Countries will differ in terms of the perceptions and experience of CFLs, as well as people's motives for buying them. Factors such as the year of introduction of CFLs onto the market and the number and type of CFL campaigns there have been to date, in addition to any cultural influences, will also have an effect.

The technical survey, discussed in the last chapter, demonstrated that the fixtures in the house are not necessarily the major barrier they are often thought to be. A second survey was conducted to investigate the extent to which other views held about CFLs are true in practice. By comparing opinions on CFLs held by owners and non-owners, it is possible to identify how perceptions of CFLs differ between these two groups. This survey also focused on the type of light people actually want in their homes and to establish how this fits with their current perceptions of CFLs and therefore identify the most suitable locations for these bulbs. In combination with the technical survey, it is possible to identify if suitable fixtures are actually found in these locations. In addition to the three partner countries, Spain was also included in this survey, enabling cross-country comparisons of attitudes to lighting and CFLs between both Northern and Southern European countries. Further details on the analysis of the results can be found in Chapters 6 and 7 of the Supporting Material.

7.1 SURVEY METHODOLOGY

A telephone survey was undertaken during July 1997 by the Fine Fieldwork Company on a randomly selected sample of at least 150 people in each of four countries: Germany, Sweden, the UK and Spain. Whilst there was a bias in the sample towards people that own a telephone, quotas for age, sex and socio-economic group were fulfilled to ensure that the sample was nationally representative for these criteria. Despite this, figures for CFL ownership and awareness were somewhat higher than the national average, although it is not clear why this should be (Table 7-1).

Table 7-1 CFL ownership and awareness: cultural survey in Germany, Sweden, UK and Spain

	Germany	Sweden	UK	Spain
CFL awareness (%)	93	67	79	78
Households with CFLs (%)	51	32	27	27
Average no. CFLs per household	2.2	1.4	0.7	1
CFLs per owning household	4.3	4.5	2.6	3.8
Number of households	150	152	157	150

The interviews were conducted by native speakers from each country and covered the following key areas (a copy of the questionnaire is included in Chapter 6 of the Supporting Material):

- The type of lighting preferred for selected household activities
- Main reasons for having or not having CFLs
- Opinions and knowledge of CFLs

Respondents were asked to select an adjective that described the type of light they wanted for the following activities: cooking, watching TV, eating, dressing, reading, receiving visitors, relaxing and listening to music, using hallways and stairs, and young children's activities. They were asked to give both a first and second choice of adjective.

The key adjectives used to describe lighting were difficult to identify. Country differences became apparent when designing the questionnaire - some adjectives did not translate into words that would be used to describe lighting in other languages. Other adjectives were considered to have negative connotations with regards to lighting in one language whereas it was a positive description in another language. Five adjectives were chosen to given a range of options for each country (Table 7-2).

Table 7-2 Translations of adjectives: cultural survey in Germany, Sweden, UK and Spain

Germany	Sweden	UK	Spain
Klar	Klar	Clear	Clara
Weich	Mjuk	Soft	Suave
Natürlich	Naturlig	Natural	Natural
Hell	Skarp	Bright	Brillante
Behaglich	Mysig	Cosy	Acogedora

The questionnaire was also completed by the 72 householders in the technical survey, giving a detailed insight into the extent to which people's perceptions of light match up to what they actually have installed in their homes. A comparison between the two surveys can also help identify how the potential identified in the technical survey to install CFLs in 42-46% of the existing fixtures might be accessed.

7.2 WHAT DO PEOPLE WANT FROM THEIR LIGHTS?

For each of the four countries, the majority of responses for all activities were dominated by two adjectives:

- Germany: bright and cosy
- Sweden: clear and soft
- UK: bright and soft
- Spain: clear and soft

‘Natural’ did not feature as an important quality of light as the first choice in any of the countries, although it was the strong second choice in most countries for eating, dressing and children’s activities. Allowing for the different interpretations of the words in the various languages and for ease of analysis, the adjectives can be considered to fall into three distinct groups: clear/bright, soft/cosy and natural.

Among the countries, particularly Germany, Sweden and the UK, there was a large degree of similarity in the adjectives chosen for each activity (Table 7-3). On the whole, Spanish householders showed a greater preference for bright/clear light, possibly reflecting the sunnier climate in Southern Europe. There was a significant difference in the type of light preferred when entertaining visitors and eating: the Spanish choosing bright/clear light rather than soft/cosy light as in the other three countries.

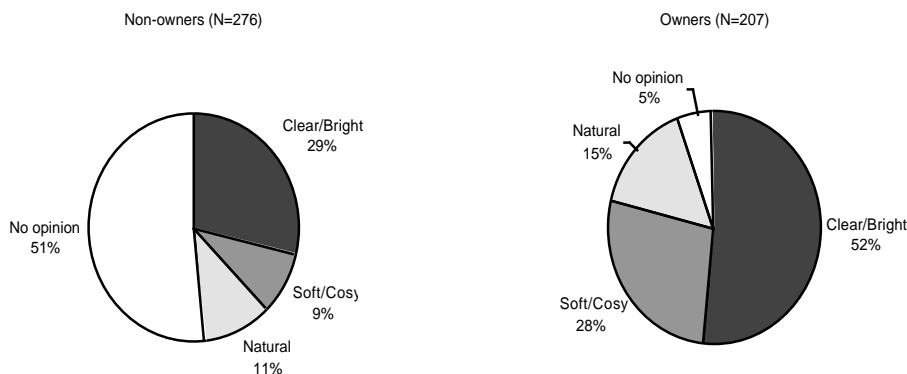
Table 7-3 Most common lighting requirements for selected activities: cultural survey in Germany, Sweden, UK and Spain

Activity	Germany	Sweden	UK	Spain
Cooking	Bright/Clear	Bright/Clear	Bright/Clear	Bright/Clear
Dressing	Bright/Clear	Bright/Clear	Bright/Clear	Bright/Clear
Reading	Bright/Clear	Bright/Clear	Bright/Clear	Bright/Clear
Using Hallways/Stairs	Bright/Clear	Bright/Clear	Bright/Clear	Bright/Clear
Children’s Activities	Bright/Clear	Bright/Clear	Bright/Clear	Bright/Clear
Eating	Soft/Cosy	Soft/Cosy	Soft/Cosy	Bright/Clear
Receiving Visitors	Soft/Cosy	Soft/Cosy	Soft/Cosy	Bright/Clear
Relaxing	Soft/Cosy	Soft/Cosy	Soft/Cosy	Soft/Cosy
Watching TV	Soft/Cosy	Soft/Cosy	Soft/Cosy	Soft/Cosy

Base: 609 surveyed households

7.3 HOW DO PEOPLE PERCEIVE CFLS?

Just under 80% of all households surveyed were aware of CFLs, 57% of these being non-owners. These respondents (both owners and non-owners) were asked to rate the quality of light from a CFL in terms of the same adjectives (Figure 7-1). Over half of these non-owners had no opinion, while the majority of those who did considered the light to be ‘clear/bright’. Spain was the only country in which ‘natural’ light was the dominant choice among non-owners (16%) and also had the highest proportion of non-owners who did not express an opinion (66%).

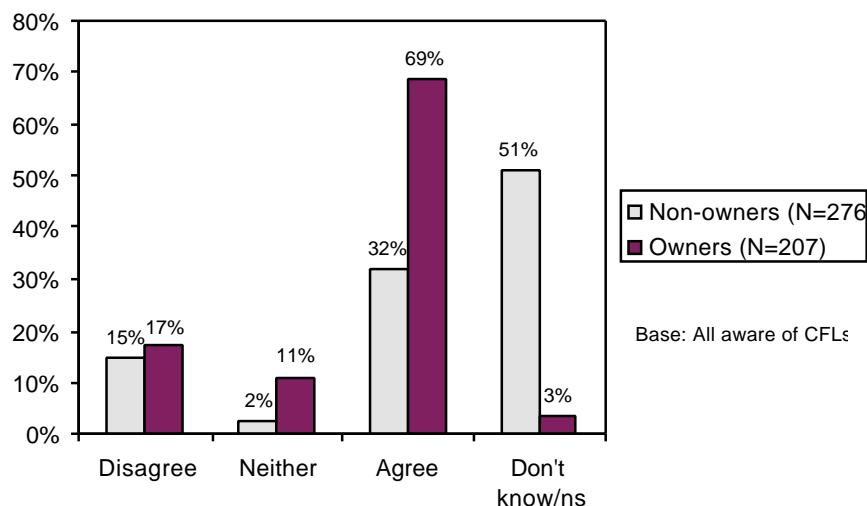


Base: all aware of CFLs (N=483)

Figure 7-1 Perceptions of light produced by CFLs among CFL owners and non-owners (all countries): cultural survey in Germany, Sweden, UK and Spain

Among owners, the majority did express an opinion, with 'clear/bright' light also being the most popular choice. Relatively more owners than non-owners considered the light from CFLs to be 'soft/cosy', while the proportion viewing the light as 'natural' was similar in both groups. In the UK, 'soft/cosy' was actually the most popular description of CFLs among owners (43%), while in German and Sweden, 'clear/bright' was dominant (65% and 66%). In contrast to the other three countries, opinions were evenly distributed between the three groups of adjectives among owners in Spain.

A large shift in opinion between owners and non-owners was also demonstrated in responses to the statement 'CFLs provide a good light for all my activities' (Figure 7-2). More than two-thirds of owners agree with this statement, over double the number of non-owners. Spain had both the largest percentage of non-owners who did not express an opinion (62%) and the greatest proportion of owners who agreed with the statement (83%). Negative views were strongest in Germany where 28% of non-owners and 22% of owners did not think CFLs provide a good light for all activities.



Base: all aware of CFLs

Figure 7-2 Responses to the statement 'CFLs provide a good light for all my activities' (all countries): cultural survey in Germany, Sweden, UK and Spain

Of the 34% of households that owned CFLs, between 79% and 90% were satisfied with them (based on how likely they would be to recommend CFLs to a friend or neighbour). Therefore, the majority of owners are happy with their CFLs, viewing them as a flexible light source, with a wide range of opinions expressed about the quality of light provided by these bulbs. A small proportion of people who used CFLs were not prepared to recommend their use to others, indicating that they were not entirely happy with them. Among non-owners there is a lack of knowledge about what a CFL can provide, even though around 70% of all non-owners in the survey were aware of CFLs. Hence it appears that it is ignorance of the technology rather than dislike of CFLs that is the reason for many households not owning CFLs.

7.4 WHY DO PEOPLE HAVE CFLS?

In order to encourage the wider use of CFLs, it is necessary to have some understanding of the perceived advantages and disadvantages of the technology. Opinions from owners, who have experience of CFLs, indicate real benefits to be gained from the use of CFLs, which non-owners may be unaware of. Establishing the reasons why people do not have CFLs indicates obstacles that need to be overcome to encourage ownership. Further comparison of views held on CFLs by owners and non-owners can identify where the misconceptions lie and which barriers are actually realised in practice by owners, therefore preventing further uptake of CFLs.

Two open-ended questions were asked to establish the attractions of CFLs and the perceived obstacles to their adoption:

- 'What would you say are the main reasons for you having CFL bulbs?' - asked only of owners (Table 7-4).
- 'What would you say are the main reasons for you not using CFL bulbs?' - asked of non-owners (Table 7-5).

At least half the respondents in each of the four countries judged financial savings, either in general or as an aspect of reduced electricity use, to be the main benefit of using CFLs. Longer lifetime is also considered to be an important attribute of CFLs by owners in all four countries. Environmental motives were stronger in Germany than the other countries, not featuring in any of the responses from Spain. Only the Spanish positively choose CFLs for the quality of the light. Differences between the countries indicate the need for careful targeting of any programme designed to encourage the uptake of CFLs.

Table 7-4 Main reasons for obtaining a CFL among owners: cultural survey in Germany, Sweden, UK and Spain

	Germany (N=76)	Sweden (N=49)	UK (N=42)	Spain (N=40)
I like the quality of light	-	-	-	40%
Electricity saving (money)	66%	53%	33%	33%
Because they last longer	24%	31%	31%	20%
Money saving general	47%	24%	36%	15%
Electricity saving (environment)	42%	12%	17%	-

Base: CFL owners (N=207)

Note: more than one answer could be given

Respondents who were aware of CFLs but did not own any were asked their main reasons for not using them. The main barrier was felt to be price in all four countries, while in Sweden, Spain and the UK many respondents had not actually considered buying them. Around one in three householders in Spain responded that they were happy with their current lighting and so there is little incentive to try out a new, unknown technology. The Germans gave the greatest range of reasons, largely concerned with aesthetic aspects of CFLs, such as the appearance or light from CFLs. These negative views may have arisen through the inappropriate application of CFLs in the past or through experience of older technology, such as the larger magnetic ballast CFLs, or low quality imports. People may not realise that more modern technology is now available.

Table 7-5 Main reasons for not using a CFL among non-owners: cultural survey in Germany, Sweden, UK and Spain

Reason	Germany (N=64)	Sweden (N=53)	UK (N=82)	Spain (N=77)
Too expensive	31%	48%	33%	34%
Never considered purchase	-	29%	30%	16%
Do not like the light from CFLs	22%	-	-	-
Unattractive	31%	-	-	-
Take too long to come on	9%	-	-	-
Not compatible with light fittings	19%	-	-	-
Happy with current lighting	-	-	-	29%
Don't know/not stated	8%	13%	10%	1%

Base: non-owners aware of CFLs (N=276)

Note: more than one answer could be given

Therefore, in Sweden, the UK and Spain it is not dislike of CFLs that is preventing people using them. Greater awareness of the advantages and flexibility of CFLs, as judged by owners, could be effective in persuading these people to try out their first CFL in order that they may experience the benefits themselves. In Germany, this may prove to be more difficult since there is a generally negative perception of CFLs among non-owners.

Comparing the responses of owners and non-owners to a series of statements regarding CFLs indicates the opportunities that exist to encourage non-owners to use CFLs and the extent to which views held by non-owners are borne out in practice among owners (Table 7-6). While there is general agreement between owners and non-owners on the majority of statements, the high proportion of non-owners in the 'don't know' category further highlights their lack of knowledge and experience of CFLs.

Most non-owners were unaware of the benefits of CFLs. There was most uncertainty among both owners and non-owners about how long CFLs last in practice, with the majority of non-owners also unsure if CFLs save money in the long run. An equal proportion of owners and non-owners actually disagreed with this statement. These responses imply a lack of confidence in the technology. The convenience of CFLs was recognised by owners and non-owners, with both groups agreeing strongly. Fewer respondents, particularly non-owners, were aware that a major advantage of CFLs is that they get less hot. The environmental benefits of CFLs were recognised by a high percentage of respondents, although, again, the majority of non-owners did not have an opinion on this.

Around one in ten owners and non-owners felt that they are restricted in their choice of light bulbs, while owners are more likely to feel they are expected to buy CFLs, possibly perceiving themselves as 'green consumers'. A fair proportion of owners and non-owners considered CFLs to be unattractive which may, therefore, be preventing their wider use, particularly in fixtures where the bulb is visible. While this could be tackled through improved bulb design, dedicated fixtures may be a better solution. Most owners considered CFLs to provide a good light for all their activities but were also aware that they are not suitable for all their fixtures. This identifies the fixture, not the bulb, as the perceived constraint, and further emphasises the need for dedicated fixtures.

Table 7-6 Summary of responses to statements about CFLs (all countries): cultural survey in Germany, Sweden, UK and Spain

	Owners			Non-Owners		
	Disagree	Agree	Don't know	Disagree	Agree	Don't know
I don't have any choice over the type of bulbs I buy	83%	12%	3%	53%	3%	33%
CFLs are convenient/don't have to be changed often	7%	87%	5%	0%	52%	43%
CFLs provide good light for all my activities	17%	69%	3%	15%	32%	51%
CFLs don't last as long as they say	58%	12%	28%	18%	8%	69%
CFLs don't save money in the long run	65%	12%	17%	29%	13%	55%
CFLs are environmentally friendly	4%	74%	18%	2%	46%	51%
CFLs have an attractive appearance	41%	42%	3%	28%	25%	42%
My friends think I should buy CFLs	17%	38%	31%	22%	14%	58%
CFLs protect the light fittings (less hot)	5%	67%	25%	4%	32%	60%
CFLs are not suitable for all my light fittings	26%	58%	12%	17%	31%	50%

Base: all aware of CFLs (N=483)

7.5 LINKING WITH THE TECHNICAL SURVEY

The interaction between the bulb and the fixture is crucial in determining the quality of light provided. If CFLs are to provide the type of light people want for various tasks, as identified in the cultural survey, they require appropriate fixtures. The technical survey found the majority of existing fixtures in the home to be unsuitable for CFLs. These fixture types would therefore be an appropriate target for dedicated fixtures, designed to provide the desired quality of light for particular locations. For instance, a high proportion of wall fixtures, often in high usage areas such as the living room, were unsuccessful conversions in all three countries. These therefore represent a good opportunity for dedicated fixtures providing a soft/cosy light.

Results from the cultural and technical surveys demonstrate that one of the main barriers to the adoption of CFLs is the lack of experience and knowledge, rather than any particular dislike or suspicion of them. A better understanding of how a CFL and fixture interact are needed to enable more people to use them appropriately. The cultural survey demonstrated that owners are satisfied with the CFLs they own and view them as a flexible light source, suitable for a wide range of applications. Therefore there is no reason why the potential to use CFLs in the existing fixtures, identified in the technical survey, could not be realised by the householder given the necessary knowledge.

7.6 CONCLUSIONS

The cultural survey reveals greater similarities in people's lighting requirements between the three Northern European countries of Germany, Sweden and the UK compared to Spain. There is a stronger preference for clear/bright light in Spain, while the expectation that the Swedes would want cosy/soft light was not borne out by the evidence.

CFLs are perceived as providing a clear/bright light by the majority of owners in Germany and Sweden, whereas opinions were more evenly distributed in the UK and Spain, natural light being a popular choice among the Spanish. Among those non-owners who expressed an opinion, the majority also considered CFLs to provide a clear/bright light. In all countries, there was a shift in perceptions of CFLs between owners and non-owners, with a greater proportion of owners viewing CFLs as giving a soft/cosy light.

Common to all four countries was the lack of opinion expressed by non-owners on the characteristics and performance of CFLs, with few expressing strong negative opinions. Many non-owners had not actually considered purchasing CFLs. There is no real incentive for them to do so, particularly if they are happy with their current lighting. Therefore, people are more likely not to own CFLs through ignorance, rather than because of a dislike of the bulbs. Non-owners need to be shown that CFLs can match their requirements and their fixtures, but they will require guidance on how and where to use them in order to gain maximum benefit and satisfaction.

On the whole, owners are satisfied with their CFLs, although they were not always positive about them. The Germans expressed the strongest negative views about CFLs, the environment being a stronger motive for installing CFLs than their performance or aesthetics. In Spain, people chose to have CFLs because they like the quality of light. The main benefit of CFLs is judged to be the financial savings that can be made, whereas the main barrier to their adoption is the high initial cost and the majority of non-owners were unaware that CFLs save money in the long run. There was also uncertainty about the technology, even among owners.

Since the majority of owners are happy with their CFLs, there is no reason to expect them to change back to using ordinary incandescent bulbs, although there is a risk of reversion if they do not keep spare CFLs. A move towards dedicated fixtures would guarantee against changing back as well as ensuring optimal performance of the CFL, possibly improving peoples' level of satisfaction. Positive experience of integral ballast CFLs lays a good foundation for the introduction of dedicated fixtures. Householders would also benefit financially because of the cheaper replacement bulbs. The reduction in wastage, through incorporating the ballast into the fixture, is likely to appeal to the strong environmental motives in Germany. The cultural survey indicates the type of light that fixtures in various locations need to provide, which should help ensure their success.

Essentially, the cultural survey has succeeded in highlighting a number of key aspects of the lighting needs and perceptions of a cross-section of EU countries. Although there are limitations to the study, it has brought a better understanding of where there may be specific lighting demands for individual activities and between countries.

CHAPTER 8: CONSUMPTION TRENDS

The type of lighting people choose for their homes is dependent upon both cultural and technical factors - a combination of their attitudes to lighting and the technologies available on the market - as well as economics. The amount of electricity used for lighting depends on the way in which people then use the lights they have chosen. Hence there is a significant interplay between lighting technologies and cultural attitudes in determining lighting electricity use and hence the level of savings possible.

Reliable information on household lighting electricity consumption is not available for the majority of European countries. Studies monitoring consumption, either through hours of use or actual consumption, are costly and difficult to set up, often requiring separate metering equipment for each light. Measuring lighting electricity use is particularly difficult for fixed lights if they are connected to the general electrical circuit in the house, since there is no easy way of identifying the amount of electricity going into lighting alone. Hence, in many studies, lighting electricity use is often included in the miscellaneous category of electricity remaining when other end uses of electricity have been monitored.

Models of consumption provide an easier and cheaper alternative to improving estimates of lighting electricity use. This still requires a variety of data such as sales, ownership, average wattage of installed bulbs, and confidence in the model output is highly dependent on reliability of the input data. Due to the lack of such data, lighting consumption in all fifteen EU Member States could not be modelled, as was originally intended. As part of the detailed case studies of Germany, Sweden and the UK, sales data were purchased in order to model lighting consumption in these three countries. Actual measurements of household lighting consumption are useful to validate the model output. However, such figures were only available for the UK for this study.

A brief outline of the modelling process is given, taking a 'stock model' approach, before presenting results of the three scenarios modelled. The Reference Case (RC) scenario provides a base line for past and future lighting consumption. The other two scenarios, the Economic and Technical Potential (ETP) and the Fixtures and Immediate Technical Potential (FITP), illustrate the potential level of savings that are available through the installation of more energy-efficient lighting. More details on the modelling process and results are included in Chapter 8 of the Supporting Material.

8.1 MODELLING LIGHTING CONSUMPTION

Lighting electricity consumption was modelled using a 'stock' model approach that takes into account the time-related effects of new bulbs entering and old ones leaving the stock and enables the evaluation of the likely effect of policy options on consumption. This type of model is essential for analysing the effect of changes in technology or usage through time.

Stock models estimating lighting electricity use were constructed using a bottom-up approach (ie from the household perspective, rather than a top-down econometric approach), based on the data listed below. Ownership figures were checked by comparing them to figures derived from sales data and expected bulb life spans. The model outputs were then cross-checked against measured consumption data. The data used were:

- number of households,
- average household ownership of each bulb type,
- sales of each bulb type to the domestic sector,
- average wattage of these bulbs,
- expected average lifetime of these bulbs and
- measured household lighting electricity consumption data.

The actual data obtained for each of the three countries varied in quality and completeness, although missing data could be interpolated to some extent from what was available. In some cases, it was necessary to use results from the technical surveys, conducted as part of this project. Despite the fact that these were based on very small samples and were not nationally representative, they were valuable in the absence of other data. Light bulb sales data were purchased from the same market research company, GfK, for all three countries to ensure the maximum comparability and compatibility of data. A summary of the ownership figures used in the RC scenario is given in Table 8-1, including projections to 2020 based on the identified trends and expert judgement.

Table 8-1 Average household light bulb ownership, Germany, Sweden and UK, 1970, 1997 and 2020

	Germany			Sweden			UK		
	1970	1997	2020	1970	1997	2020	1970	1997	2020
Household numbers (m)	27.9	37.8	41.2	2.6	4.1	4.7	16.1	24.2	28.5
Total number of bulbs	10.4	30.3	33.2	13.8	40.4	44.3	11.0	20.1	24.0
Number of CFLs	0.0	2.1	3.9	0.0	0.4	1.8	0.0	0.7	3.2
Number of halogens	0.0	2.0	2.5	0.0	2.6	3.3	0.0	0.1	0.4
Number of fluorescent strips	0.5	2.1	1.4	0.7	2.8	1.9	0.5	1.4	1.0
Number of incandescents	9.8	24.9	25.5	13.1	34.5	37.4	10.4	17.9	19.4

Many of the figures used as inputs to the models are not exact, but represent best estimates, so the output of the models include expert judgement. The level of confidence in these results are shown by confidence limits on the consumption graphs (Chapter 8, Supporting Material). Uncertainty is greater the further into the future data are projected and confidence is lowest in the estimates for Germany since data were particularly limited.

8.2 REFERENCE CASE AND SAVINGS POTENTIAL

The Reference Case scenario gives historical lighting consumption, from 1970, with a projection up to the year 2020. The projections of usage and ownership and the underlying rate of technology change are determined from historical trends where possible. The only policy interventions allowed for are those that have been implemented or are close to implementation at the national or EU level, although the effect of the EU Energy Label on bulbs is not included.

Two scenarios were modelled to illustrate the level of savings available for lighting: the Economic and Technical Potential (ETP) and the Fixture and Immediate Technical Potential (FITP). These are both technical scenarios in that they are based on changes in the rate of introduction of efficient technology (CFLs), rather than any change in behaviour and so may not represent the lowest levels of consumption achievable. They assume the same overall trends in total bulb ownership and hours of usage as the RC scenario, the difference being in the timing and extent of the switch from GLS bulbs to CFLs. Ownership of halogens and fluorescent strips are kept the same as the RC scenario and there is no introduction of other technologies, such as the IEA 'future bulb'.

The Economic and Technical Potential (ETP) is technically feasible and cost-effective to the consumer. However, what is considered cost-effective depends on the price of the bulb, the cost of electricity, the lifetime of the bulbs and the discount rate chosen - all these parameters will vary through time. For instance, the cost of CFLs is already decreasing and will be reduced even further by a shift to dedicated fixtures, improving cost-effectiveness and altering the ETP level. Therefore, the ETP scenario described here is an illustration of what could be achieved given current technology and prices. The definition of ETP requires the cost of a product to be paid back within its lifetime. Given the long life of CFLs, the average time a CFL would last in a home with a majority of CFLs would be around 12 years - some bulbs in lower use areas could last up to 30 years. Therefore it can be considered cost-effective, within the definition of ETP, to replace 80-85% of incandescent bulbs with CFL bulbs (DECADE 1997), assuming no constraints are posed by the existing fixtures in the house. Obviously, it is unrealistic to expect the ETP level to be reached by 2002, as in the model, but this is intended as a theoretical scenario to provide a target for policy and is only one illustration of how a certain level of savings could be achieved. An appropriate policy strategy is discussed in Chapter 9.

The Fixture and Immediate Technical Potential (FITP) scenario recognises that there are constraints from the fixtures already in the home - not all of them will take a CFL. Some fixtures take halogens or fluorescent tubes and will continue to do so. Of the remainder with incandescent bulbs, 46% in the UK (42% in Germany and 43% in Sweden) are in fixtures which are suitable for CFLs and could therefore be replaced immediately. For this scenario, it is assumed that 46% of GLS bulbs have been replaced by a CFL by 2002. It is also assumed that, beyond 2002, all new fixtures purchased as part of the natural turnover of the stock are suitable for CFLs. Since few data are available on the rate of turnover of fixtures, the final assumption is that all fixtures are capable of taking a CFL by 2020, thus reaching the ETP level of 80-85% of GLS bulbs being replaced by CFLs. This is a conservative approach as other developments in the technology of low-energy bulbs could take place, for instance CFLs could become smaller and suitable for a wider range of fixtures. In

addition, savings beyond this level would be possible through the use of other energy-efficient technologies, such as the IEA ‘future bulb’, although these have not been modelled here since the emphasis is on CFLs.

The FITP is an important output from this study. It provides a realistic policy target and demonstrates the importance of treating the luminaire as a whole.

8.2.1 UK

Total residential lighting electricity consumption in the UK is 17 TWh in 1997, projected to rise under the RC scenario to 23 TWh by 2020 (Figure 8-1). Prior to the detailed research done by DECADE for the construction of a lighting stock model (DECADE 1995, 1997), total electricity use for lighting was estimated to be around 8TWh in 1997. This major revision to the lighting consumption figures has recently been confirmed through a study metering lighting undertaken by the UK Electricity Association (Palmer 1997, EA 1998). The DECADE stock model approach has been validated. The increase in consumption into the future is driven by a combination of rising number of households and a trend towards more bulbs per household.

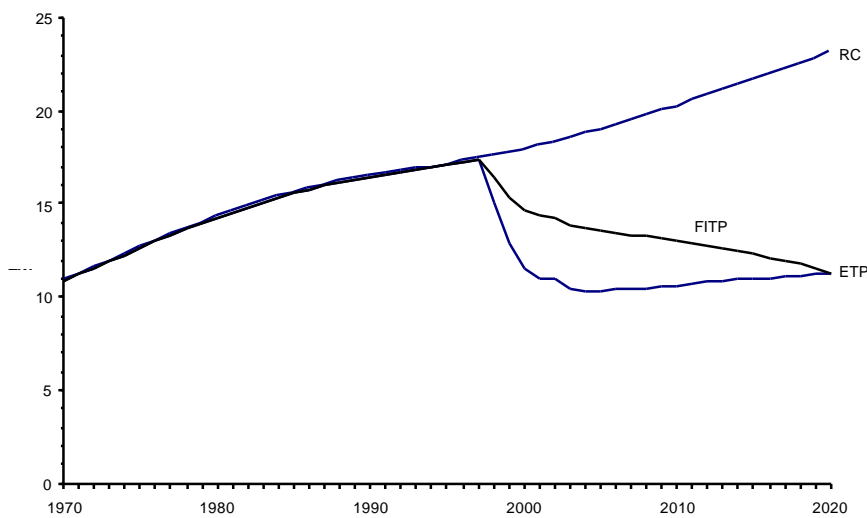


Figure 8-1 UK lighting electricity consumption under RC, FITP and ETP scenarios, 1970-2020

Lighting electricity consumption could be reduced to almost a half by 2020 as a result of switching to a majority of CFLs under the ETP and FITP scenarios. This represents a saving of over 400kWh per household.

8.2.2 Sweden

Domestic lighting electricity consumption in Sweden is estimated to be around 3 TWh in 1997 and projected to rise to around 3.5 TWh by 2020 under the RC scenario (Figure 8-2). This is mainly due to rising household numbers - average household lighting consumption actually falls over this period because of a greater proportion of CFLs and a decrease in the wattage of GLS bulbs used. Sweden is undertaking a major campaign to get three CFLs into every home by 2005 as part of the national programme to phase out nuclear power. This campaign is assumed to be successful in the projections. Despite higher numbers of bulbs in Swedish households, the average consumption per household (Unit Energy Consumption or UEC) of 760 kWh is similar to the UK figure of 720 kWh since the majority of these bulbs are of low wattage. The prevalence of low wattage bulbs means that potential savings are correspondingly lower, although savings of 36% by 2020 are still available under the ETP and FITP scenarios.

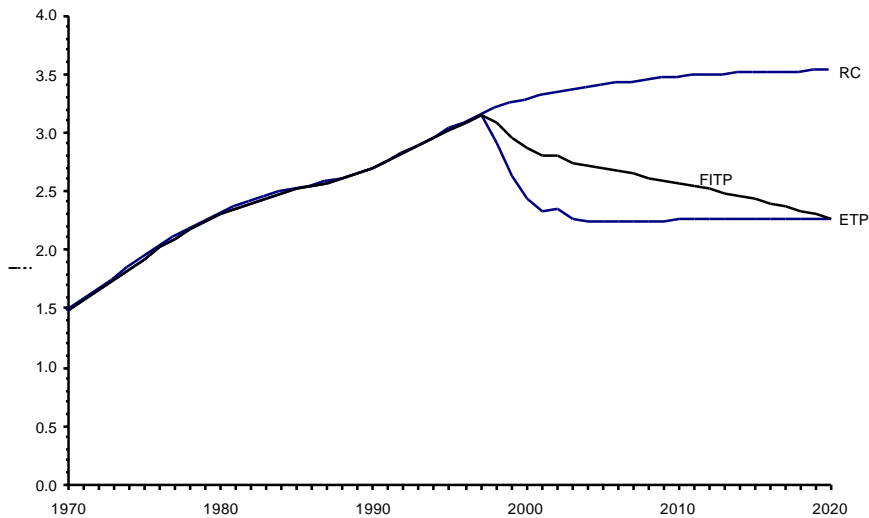


Figure 8-2 Swedish electricity consumption under RC, FITP and ETP scenarios, 1970-2020

8.2.3 Germany

In Germany, domestic lighting consumption is around 30TWh in 1997, only rising to 33TWh by 2020 under the RC scenario (Figure 8-3). Any increase in consumption due to the growth in household numbers and the expected trend towards high wattage halogens is offset by the lower wattage of GLS bulbs and an increase in CFL ownership. Average household lighting consumption is the highest of the three countries, at 775 kWh. As with the UK, this figure is far higher than previous estimates of lighting consumption, over double the official estimate of 300 kWh (VDEW 1997). It should be remembered that the stock model figures are the best estimates of consumption and are not exact - the true figure may lie somewhere between 450 kWh and 1100 kWh. However, even this lower limit is above previous estimates and actual household electricity consumption is more likely to be similar to that in the UK and Sweden. A detailed stock model has demonstrated the importance of domestic lighting in Germany: this will alter the emphasis given in policies.

It is not been possible here to identify the differences that may exist between former East and West Germany. Information gathered on the Eastern European countries in the country pictures indicate that these households are more likely to have lower lighting consumption than in the West. Therefore, while the figure of 775 kWh per household represents an average for all Germany, since it is based on sales figures for the whole country, there may be a very wide range in consumption between different households underlying this.

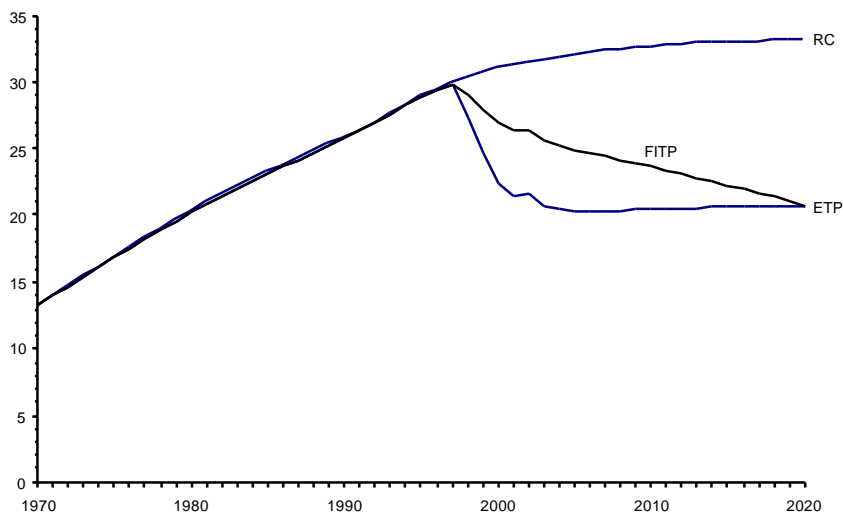


Figure 8-3 German electricity consumption under RC, FITP and ETP scenarios, 1970-2020

As in the case of Sweden, potential savings in Germany are lower than the UK because of the use of lower wattage GLS bulbs. Savings of 38% by 2020 are achievable under the ETP and FITP scenarios.

8.3 DISCUSSION OF RESULTS

8.3.1 Reference case

Average household lighting consumption is similar in all three countries (Table 8-2), despite differences in the number and type of bulbs found within households. This is partly because any savings resulting from the use of lower wattage GLS bulbs in Germany and Sweden are offset by the high number of bulbs per household. Also, the popularity of high wattage halogens in these two countries serves to increase consumption, thus negating any savings achieved through the higher ownership of CFLs in Germany. Total lighting consumption in each country is projected to increase into the future under the RC scenario, mainly driven by the growth in household numbers. There is also an expected trend towards more bulbs per household in the three countries, due to growing interest in lighting. This upward pressure on consumption is partly compensated for by an increase in CFL ownership. Hence, household lighting consumption decreases in Sweden while remaining fairly constant in Germany. In the UK, average household electricity consumption increases because the growth in CFL ownership is not enough to allow for the additional GLS bulbs in the stock, which are generally of a higher wattage than in the other two countries.

Table 8-2 Domestic lighting electricity consumption, RC scenario, Germany, Sweden and UK, 1997 and 2020

	<i>Germany</i>		<i>Sweden</i>		<i>UK</i>		<i>TOTAL</i>	
	<i>1997</i>	<i>2020</i>	<i>1997</i>	<i>2020</i>	<i>1997</i>	<i>2020</i>	<i>1997</i>	<i>2020</i>
Household numbers (m)	37.8	41.2	4.1	4.7	24.2	28.5	66.1	74.4
Household UEC (kWh)	775	805	762	749	721	811	758	804
Household expenditure (ecu)	125	129	61	60	72	81	102	106
Household carbon (kg C)	132	134	0	0	88	139	107	127
National electricity (TWh)	29.5	33.1	3.1	3.5	17.4	23.1	50.1	59.8
National carbon (MtC)	4.9	5.5	0.0	0.0	2.1	4.0	7.1	9.5
National expenditure (mecu)	4.7	5.3	0.3	0.3	1.7	2.3	6.7	7.9

Note: UEC - Unit Energy Consumption (average lighting electricity consumption per household)

In terms of CO₂ emissions, lighting in Germany is the most polluting given the dependence on fossil fuel electricity generation, high household numbers and highest levels of lighting consumption. Such emissions are minimal for Sweden because of the low percentage of fossil fuel generation, with 96% of generation from hydro-electric or nuclear power stations. Sweden is aiming to lower total electricity consumption and so reduce dependence on nuclear power, switching to renewable sources such as wind and hydro power instead. Actual emissions factors for Sweden were not available, but since CO₂ emissions are likely to be low they have been set to zero. The conversion factors used to derive the expenditure and CO₂ emissions are given in Table 8-3.

Table 8-3 CO₂ emissions conversion factors, Germany, Sweden and UK

	<i>Germany</i>	<i>Sweden</i>	<i>UK</i>
ECU/kWh - 1997	0.16	0.08	0.10
ECU/kWh - 2020	0.16	0.08	0.10
kg C/kWh - 1997	0.202	0.0	0.12
kg C/kWh - 2020	0.166	0.0	0.17

Sources: Country pictures and

Germany - Prognos AG (1995)

UK - DECADE (1997) based on EP 65 (1995)

8.3.2 Potential savings

Table 8-4 summarises the potential savings available under the FITP and ETP scenarios. These are identical for the two scenarios since they have both reached the same end point by 2020, the difference being the speed with which this was achieved.

It can be seen that a wide range of factors impact on figures for lighting consumption, including the number of households, the number of bulbs and the wattage of these bulbs. While some data are available to provide information on the current situation, attempting to identify future trends is far more difficult. However, since the figures estimated under all three scenarios are subject to the same likelihood of errors, estimates of future savings (RC less the FITP/ETP figures) are more reliable.

Table 8-4 Lighting electricity consumption and potential savings (electricity, expenditure and CO₂), Germany, Sweden and UK, 2020

		<i>Germany</i>	<i>Sweden</i>	<i>UK</i>	<i>TOTAL</i>
FITP/ETP	Household UEC (kWh)	502	482	398	461
	National electricity (TWh)	20.7	2.3	11.3	34.3
	National carbon (MtC)	3.4	0.0	1.9	5.4
	National expenditure (mecu)	3.3	0.2	1.1	4.6
Saving (RC-FITP)	National electricity (TWh)	12.4	1.3	11.8	25.5
	Percentage of RC	38	36	51	43
	National carbon (MtC)	2.1	0.0	2.0	4.1
	National expenditure (mecu)	2.0	0.1	1.2	3.3

Taking the constraint of the existing fixtures into consideration, as in the FITP scenario, only about half of the savings to be achieved under the ETP scenario are accessed by 2002. However, by 2020, total savings of 25.5 TWh could be achieved in the three countries under both scenarios, representing almost 30% of current EU lighting electricity use. This is equivalent to savings of 4.1 Million tonnes of Carbon.

As a proportion of the RC, savings are greatest in the UK because of the current use of higher wattage GLS bulbs compared with Sweden and Germany.

8.4 CONCLUSIONS

Detailed modelling of lighting electricity consumption has led to major revisions of previous estimates of lighting consumption in both Germany and the UK. The confirmation of the revision to the UK figures through actual measurements of lighting consumption gives greater confidence in the output of the stock model. Therefore, although no metered data are available for Germany at present, it is likely that lighting consumption is also far higher than previously thought. Hence lighting is more important as a policy focus since the potential savings are also much greater than thought. These revisions serve to underline the advantages of modelling as a way of checking estimates of lighting consumption.

The potentials for savings in this sector are large and quick to access, given the high turnover rate of bulbs in the stock. These exclude any behavioural change and therefore savings could possibly be greater.

The ETP scenario defines an envelope of savings, with the FITP scenario illustrating how this potential could be reached over a realistic time scale, once the existing fixtures are taken into account. In order to access these savings, appropriate policies are required, as discussed in the next chapter.

CHAPTER 9: POLICY

Following Kyoto, the residential lighting sector is particularly important as savings are both substantial and potentially available quickly. Without policy intervention, any reductions in consumption are likely to be realised slowly, if at all. In the past, policy has focused on other groups of domestic appliances, for instance there has been an EU Energy Label on refrigeration equipment since 1995 and on washing machines and tumble dryers since 1996. The opportunities for additional savings from the domestic lighting sector are now being considered.

A stronger focus on lighting is only one of the results of the climate change agreements reached in Japan in December 1997, the other new emphasis is on the need for guaranteed savings. The members of the European Union are collectively committed to reducing their emissions of carbon dioxide to 8% below the 1990 level by 2010. The effect of this commitment is that the outcome of policy must have a degree of certainty that was not previously necessary.

An estimate of lighting electricity consumption for the EU has been made based on the detailed modelling for Germany, Sweden and the UK presented in Chapter 8. The figures for all three scenarios (fully described in Chapter 8) have been extrapolated on the basis of the number of households in the EU and corrected to match the present national consumption figures, adding up to 86 TWh across the whole of the EU, given in Chapter 4 (Figure 4-1). Electricity consumption is projected to rise to 102 TWh by 2020 under the Reference Case scenario, with a conservative estimate for potential savings of 44 TWh (43%) achievable by 2020 across the EU (Figure 9-1).

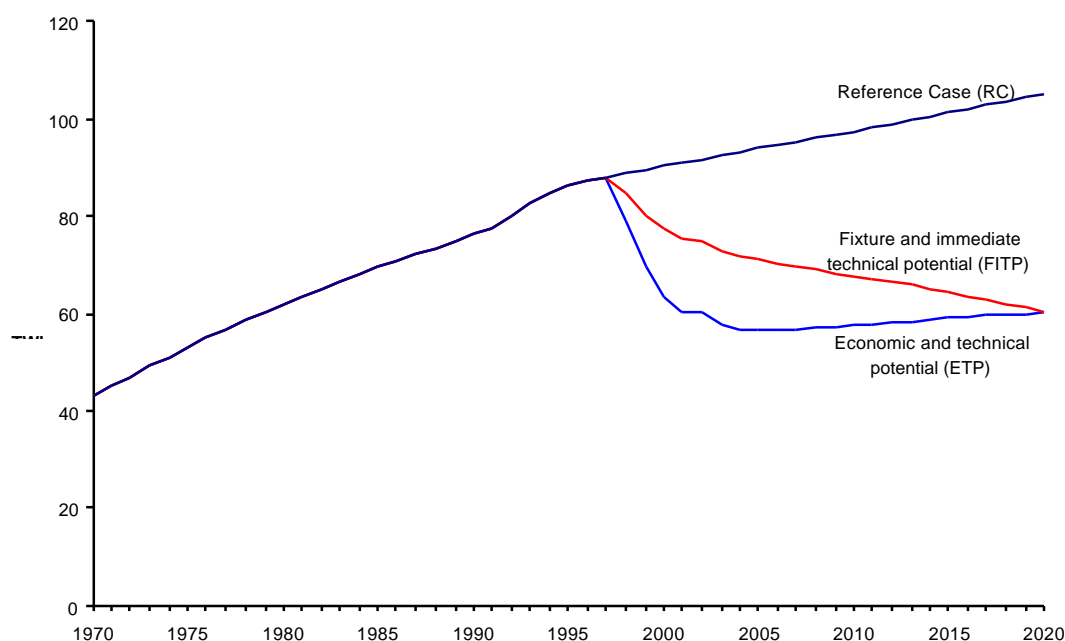


Figure 9-1 Estimated EU lighting electricity consumption under RC, FITP and ETP scenarios, 1970-2020

The ETP scenario defines the envelope of savings that could be accessed through policy, with the FITP scenario an illustration of one way in which this could be achieved. The FITP scenario is based on the finding from the technical survey that it is technically and aesthetically feasible to install CFLs in at least 40% of fixtures currently using incandescents, equivalent to around eight CFLs per house. Given the natural rate of turnover of bulbs, this is realistically achievable within five years. Following on from this, it is assumed that all fixtures purchased, either new or replacement in the natural turnover of the stock, are dedicated to CFLs. Therefore, by 2020, 80% of all bulbs in the household are CFLs. The largest savings will come from installing CFLs in the highest used locations - the technical survey demonstrated that by replacing only four bulbs in the highest use locations which are suitable for CFLs, annual savings of 200 kWh per house can be achieved. These need to be targeted first in order that later replacements become economically favourable. The only

barrier to achieving this potential, given sufficient availability of CFLs, lies in persuading the householders to make the change.

Lighting is a particularly complicated sector for policy, because there are both bulbs and fixtures. These two technologies have different manufacturing industries and are sold through separate retailing structures, making a total of four groups of companies, briefly summarised in Table 9-1. These four groups have not traditionally co-operated, but collaboration will be important if the potential savings are to be realised.

Influencing the fixture industry in a coherent strategy is potentially difficult because of the large number of small, independent companies and because of imports from outside of Europe. The current market is still dominated by fixtures produced within Europe, but competition from the Far East is increasing. The luminaire retailers have potentially the most significant role in transforming domestic lighting. The absence of a trade perspective - there are few large chains of lighting shops - may inhibit this development and indicates why external schemes, such as accreditation, may be necessary.

Table 9-1 Main constituents of domestic lighting manufacturing and retailing markets

	Manufacturers	Retailers
Bulbs	Three large multi-national companies	Supermarkets
Fixtures	Numerous, small, often country-specific	Specialist shops, department and DIY stores

There are further complexities specific to lighting, in addition to those found with all other domestic appliances where market transformation is now the accepted policy strategy. Lighting policy options have to recognise that:

- there is multiple ownership of light fixtures in the home, requiring multiple interventions, over a long time period;
- lighting is used by different people for a variety of tasks and attitudes to ‘acceptable’ light vary in households and across countries;
- each fixture has a different usage pattern which implies differing levels of cost-effectiveness when replacing with more energy-efficient alternatives;
- ownership of fixtures varies across Europe, from being personal possessions in some countries to part of the fabric of the house in others;
- the replacement rate of bulbs is rapid, but turnover is slower for fixtures.

9.1 POLICY FOCUS

The synergies available from a strategic policy approach are greater in lighting than with other appliance groups. This is because there has been relatively little attention paid to lighting so far and because of the additional benefits available when the fixtures and the bulbs are both considered. In addition to the fragmentation of the industries involved and the need for certainty, this project has, through findings and through debate, established the major objectives for a market transformation policy on lighting in Europe.

There are two main policy phases, in parallel:

- **to get the first CFL into those households that have none as soon as possible.** One of the key findings is that, throughout Europe, those households that have a CFL have an average of three or four. However, there are still around 70% of households that currently have no CFLs. The non-users are either unaware that CFLs exist or uncertain about their attributes. The owners, however, are generally positive about the quality of light and other benefits of CFLs, which can explain why they have several in the house. The practical experience of using a CFL seems to be vital if people are to be converted from doubters into happy users.
- **to ensure that the majority of fixtures in households are dedicated to CFLs in the longer term.** The ultimate focus of any strategy must be a move towards dedicated fixtures, so that the savings are certain and there can be no reversal to incandescent bulbs and higher consumption. This has to be a long term goal, partly because there are few attractive dedicated fixtures available at present and also because of the slower turnover of fixtures in the home. Once appropriate luminaires are designed and as people become used to CFLs in the home, then the adoption of dedicated fixtures will be both acceptable and natural.

The focus on integral ballast CFLs in the short term is, therefore, a necessary precursor and provides the opportunity for policies targeted at fixtures to be developed. The different state of the bulb and fixture markets means that they are, initially, at different stages of market transformation. The combination of these two phases and their eventual synchrony requires a coherent strategy, as in market transformation, to ensure that the savings are achievable and at a reasonable rate. Before considering the details behind policy formulation for Europe, a brief outline of the theory of market transformation is given followed by an example developed for domestic lighting in the UK.

9.2 MARKET TRANSFORMATION THEORY AND LIGHTING

Market transformation is the process by which a significant and permanent improvement in the efficiency of products sold can be brought about, more quickly than would have happened without intervention (DECADE 1997). Isolated policies have a limited impact, but they can create a powerful synergy when combined into a coherent strategy. The appropriate package and sequence of policies is specific to each product and requires consideration of the characteristics of the appliance group and wider policy objectives such as the certainty of savings, cost (to government, consumers and manufacturers) and equity between income groups.

Market transformation takes a long-term view (typically 10-15 years) using a combination of market building and market consolidation activities, both equally important:

- the first requirement is a reproducible measure of consumption and efficiency, and to incorporate this in an energy label. Once efficiency can be measured, it can be monitored and influenced;
- the market building stage aims to increase the market share of more efficient technology through, for example, procurement and rebate programmes, likely to be undertaken at the national level. The aim of these policies is to get the efficient technologies to achieve a certain proportion of the market (say 20%);
- in the market consolidation phase the aim is first to make these energy efficient technologies the average on the market and then the minimum standard. At this point, 100% of the savings are achieved. This involves instruments such as regulatory or voluntary agreements, usually implemented at the EU level. Regulatory incentives remove uncertainty and create the best climate for investment and product development.

Further details on the theory of market transformation are given in Chapter 9 of the Supporting Material or in DECADE (1997).

A market transformation strategy for lighting, including both incentives and standards, is a relatively new concept. Any programme developed will be more complex than that required for other domestic appliance markets since lighting represents two distinct but inter-dependent technologies and their associated industries - light sources and light fixtures. As depicted schematically in Figure 9-2, the components of such a strategy include labels, education, procurement, rebates, efficiency standards and regulation.

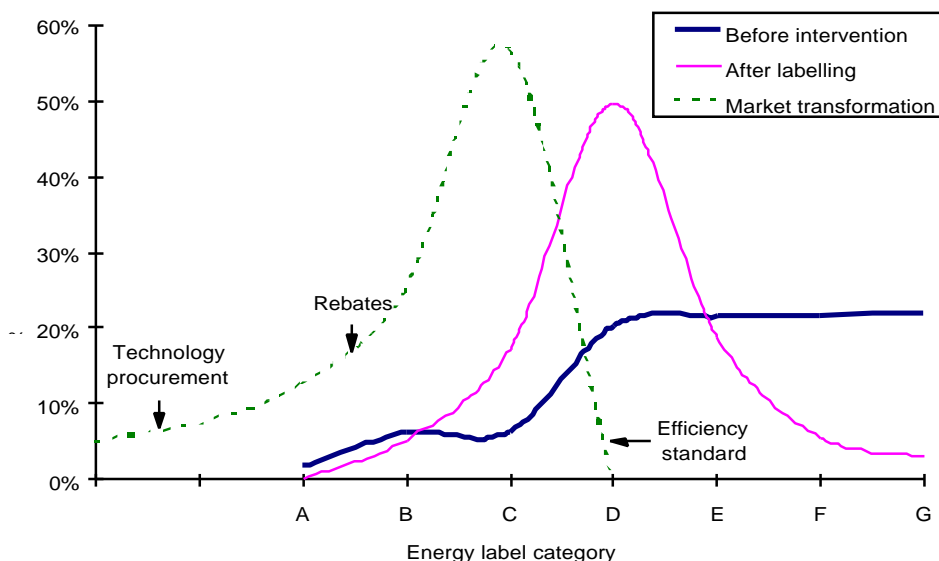


Figure 9-2 Three stages in transforming the market

Market transformation focuses on stimulating the purchase and use of more efficient technologies. It does not take account of any change in behaviour in terms of the way in which the lights are used, such as switching the lights off when they are not in use. However, information on wasted lighting energy is scarce and any such savings are likely to be minimal in comparison to what could be achieved through the installation of efficient technology.

9.3 A CASE STUDY OF THE UK

The DECADE team has developed a detailed market transformation strategy for domestic lighting in the UK, using a mixture of national and EU policies (DECADE 1997), which is summarised here to demonstrate the way in which policies could interact. It is not proposed that this is the appropriate scenario for Europe, but it provides a useful exemplar. For the UK, one of the main objectives was to achieve the ETP level by 2020 in an equitable way - low-income households should clearly benefit from the strategy.

The aim, as in Europe, is to promote integral ballast CFLs in the short term combined with building the market for dedicated fixtures as the long term goal. This scenario is constructed on the basis that there are 24 million households with an average of 20 bulbs per household in 2000. The ETP level at 2020 is equivalent to 85% of all bulbs being CFLs, which requires the market to be built up to and maintained at an annual sales volume of around 24 million CFLs. This is equivalent to one new CFL per household per year, not including replacement bulbs. The contribution of various policies towards achieving this target is illustrated in Figure 9-3.

Current market building policies at the national level are continued, such as programmes run by the Energy Saving Trust (EST) to distribute or subsidise CFLs, so that by 2003 every household has two integral electronic ballast CFLs. In addition, the EST is developing a scheme to promote dedicated fixtures and it is assumed that successful designs are manufactured and subsidised until 2005. As the average household purchases a fixture each year, whether new or replacement, the aim is for an increasing proportion of these purchases to be dedicated, so that by 2005, each home has two dedicated fixtures. Hence, in the four years from 2001, the average home will have acquired four CFLs (two of which are in dedicated fixtures).



Figure 9-3 Transformation of the UK domestic lighting market: effects of programmes to 2020

Source: DECADE 1997

The market is further developed through a retrofit programme, over fifteen years, to install dedicated luminaires in 8 million households; mainly low-income. This policy serves the function of both confirming the market for dedicated fixtures and making sure that low-income households benefit from the energy savings at an early stage. Once these policies have built the market sufficiently, specification of dedicated fixtures in the UK Building Regulations underpins the transformation. This is possible in the UK since the majority of light fixtures are considered part of the building fabric. This would affect 200 000 new homes per annum, guaranteeing future markets. These last two policies - tailored to the UK situation - complete the market building stage. In other countries, alternative national policies may be needed.

These national policies achieve 35% of all the savings. This is a substantial proportion, because of the need to ensure that both CFLs and dedicated fixtures are firmly established. With lighting, it will not be possible to regulate and prevent the sale of the less efficient technologies, such as incandescent bulbs, in the way that inefficient fridges or washing machines can be banned. This is because the householder will continue, for many years, to own fixtures that are designed for GLS bulbs and should be free to purchase these traditional bulbs. The interaction between bulbs and fixtures and the substantial number of luminaires per house requires particularly careful policy design.

The consolidation of the market implies co-operation across Europe to achieve the remaining 65% of savings. The form of this collaboration will depend upon the speed with which electricity savings are required. In this UK example, the aim is that by 2020, CFL sales will account for half of all bulb sales and around 80% of burning hours in the average household. The target could not be reached earlier, because of the large number of fixtures and bulbs involved per household. These remaining savings would be achieved through the agreement with the bulb manufacturers of an EU Corporate Average Bulb Efficiency (CABE) - see Section 9.7.2.

9.3.1 Other member states

The design of a similar strategy for other EU member states will depend on factors specific to each country at the market building stage. At the national or local government level, the importance given to lighting and to electricity will be affected by the country's target for CO₂ emissions in 2010 and whether electricity is a major source of these emissions. Other factors, such as the importance of domestic lighting as a component of peak electricity demand - the level of maximum electricity demand dictates the amount of generating capacity and distribution networks required - will determine whether the utilities will be potential collaborators. However, the role of common and co-ordinated policies, like CABE, would be the same for the whole EU. Before considering the factors that need to be covered by policies, past and existing policies are

reviewed. These demonstrate the extent to which governments are already involved in policy and what lessons can be learned.

9.4 EXISTING POLICIES

9.4.1 Past and present lighting campaigns

In many EU countries the market for integral ballast CFLs has been developed through national programmes aiming to lower peak electricity demand and reduce CFL prices. This has usually taken the form of subsidised or free CFLs supported by some combination of government, utilities, manufacturers and retailers at a regional or national level. Rebates at the point of sale have been the most common method employed, often funded by the utilities. Further details of past and present campaigns are included in Chapters 2 and 5 of the Supporting Material. Lessons learnt from these campaigns include:

- the duration of the campaign is important, with longer campaigns being more successful;
- liaison is needed between the utilities, manufacturers and retail outlets to ensure that stocks will meet demand during campaigns;
- the provision of consumer information can increase the effect of financial incentives (Mills 1991);
- there can be a large indirect effect, with an increase in CFL sales outside the campaign period (Willerstrom 1995). These may be purchases of second or subsequent bulbs from householders who are happy with their first CFL;
- involvement of the local political and administrative authorities in the campaigns often engendered a sense of local pride and responsibility which contributed to the success of these programmes (Herbert 1993);
- a 'pay-on-the-bill' approach has proved particularly successful in Denmark and the Netherlands (Mills 1991);
- giving away CFLs is more effective than through rebates or marketing alone (Thomas *et al* 1998);
- a rebate did not necessarily lower the price in the shops after the end of the promotion;
- publication of a CFL 'quality list', based on tests on reliability, helped consumer confidence;
- there was a lack of correlation between incentive levels (bulb price) and programme penetration rates, suggesting that it is the delivery mechanism that is important, with different consumer groups preferring different types of incentives (Mills 1991).

There have only been a few schemes focusing on dedicated fixtures. Sweden and Poland have run design competitions on dedicated fixtures in the past and EM (Swedish National Energy Administration) is currently running a procurement programme for energy-efficient fixtures in conjunction with Ljuskultur (Swedish National Lighting Trade Organisation). In the UK, there are plans for a dedicated fixture subsidy scheme and for the installation of dedicated fixtures in newly built accommodation provided by Local Authorities and Housing Associations.

The first phase of a more structured market transformation policy is to ensure that each household has been given a free CFL, bringing these piecemeal campaigns together. It is not clear how many of the bulbs in people's homes across Europe have been obtained as a result of these rebate and subsidy programmes - in the UK, it is around a third of all CFLs installed. Therefore, in order to work towards this objective, each country needs a list of the schemes undertaken to date, collecting any available information on the households that have already benefited.

9.4.2 Phasing out magnetic ballasts

The Commission is currently preparing a proposal for an EU directive, introducing a minimum efficiency requirement for ballasts. An energy efficiency index for bulb-ballast systems was recently agreed by the European ballast manufacturers, represented by CELMA (Committee of European Lighting Manufacturers). This provides the basis for the proposed minimum standard by progressively removing low efficiency ballasts from the market, such as the early magnetic ballast CFLs. This will be undertaken in three stages from 2002 and completed by 2008. One effect of this will be the removal of magnetic ballast CFLs from the market since high efficiency magnetic ballasts are too bulky for use with CFLs. This useful precedent demonstrates that the manufacturers recognise the benefits of concentrating the market on the more efficient CFLs.

9.4.3 EU Energy Label for light bulbs

The Energy Label for electrical household bulbs is already a developed policy: it is due to be implemented in the year 1999, but there is an interim period before it is completely mandatory in 2001. The label gives each bulb a rating on a scale of A to G, similar to the cold and wet Energy Labels, with A representing the most

efficient light source and G being the least efficient (Figure 9-4). The size will be as in the illustration, unless it has to be reduced to fit on the packaging. The rating is calculated on the basis of the wattage and light output of the bulb, giving the following classifications of current technologies (Borg 1997):

- A - tri-phosphor fluorescent lights (linear strips and pin-based CFLs) and integral electronic ballast CFLs
- B - halo-phosphor fluorescent lights (linear strips and pin-based CFLs) and integral magnetic ballast CFLs
- C - efficient halogen bulbs
- D - other halogen bulbs
- E/F - standard GLS bulbs
- G - very poor incandescent bulbs



Figure 9-4 EU Energy Label for light bulbs

The only other new information to be included, in addition to the information normally given on the packaging, is the luminous flux of the bulb (a measure of light output). The average life of the bulb (in hours) will only be included on the label if the packaging already shows information on bulb life. Efficacy of the bulb will not be stated explicitly since this was not considered to be a fair comparison between all light sources, but it can be derived from information on the luminous flux and wattage of the bulb. The impact of the label may be limited since information given for the different bulb types will vary and will therefore not be directly comparable (eg expected lifetime may not appear on the label for incandescent bulbs). However, it is hoped that it will provide greater confidence in the benefits of CFLs and help ensure the quality of these bulbs. It will also raise awareness of the label in general since light bulbs are a frequent purchase. The Energy Label is a major step towards enabling consumers in the EU to make an informed choice about the bulbs they buy and provides the basis for market transformation of the light source market.

9.4.4 Summary of present policies

Policies are already in place to ensure that householders are encouraged to use more efficient bulbs, particularly CFLs, in their homes. The market transformation process is underway, though the separate policy components are not yet part of a clear, structured and targeted strategy. The two immediate priorities are to provide consumer education on CFLs and to stimulate the design of dedicated fixtures.

9.5 PROCUREMENT PROGRAMMES AND DESIGN COMPETITIONS

Consumer demand is restricted at present due to the current lack of well-designed CFL fixtures suitable for residential use and those that do exist are usually specific to a wattage and a type of bulb - this needs to be overcome with a more standardised approach. Procurement programmes could tackle both these issues to produce well-designed dedicated fixtures that can take a range of CFLs, reflecting the flexibility of GLS bulbs and fixtures. Compatibility and comparability of technologies is crucial to the success of any move towards dedicated fixtures. People have to know that they will still be able to buy replacement bulbs for their fixtures in years to come. This will require close and continuing liaison between the bulb and fixture manufacturers. Such collaboration has been particularly effective in developing the market for halogen luminaires.

High profile design competitions, with wide media coverage, for new and original dedicated fixtures reflecting consumer priorities, would provide a good basis for any procurement programme, promoting awareness of this technology throughout the general public. A catalogue of the various designs available could also be effective in encouraging purchases and raising awareness.

The fixture market requires a slightly different approach to the bulb market, since it involves a greater number of players, including builders and architects, as well as the householder. While this provides more opportunities to influence the market through these different channels, equally transformation of this market presents more of a challenge because of the variety and diversity of fixture styles and types available. These need to be replaced by an equivalent range of dedicated fixtures.

Dedicated fixtures are already common in the commercial sector where the incentive and ability to invest in the technology is much greater - the savings, both in terms of electricity and labour costs (because the bulbs need replacing less often), are large and quickly realised. Although these fixtures may not be appropriate for the residential market, they provide a good basis for identifying successful designs. The results from the technical survey, indicating the particular types of fixtures found in high use locations and which types are currently unsuitable for CFLs, also provide guidance on where efforts for dedicated fixture design could be most effective.

9.6 THE ROLE OF EDUCATION - BUILDING A POSITIVE IMAGE

The campaigns to promote free or heavily subsidised CFLs have not always incorporated guidance to the householder on how to use the bulb effectively in the existing fixtures. Without awareness of some of the technical characteristics of both CFLs and fixtures - and the way they interact - there is a danger that people will have placed CFLs in inappropriate fixtures, resulting in poor light output and uncertainty about the technology. An efficient bulb is devalued if used in an unsuitable fixture. As outlined earlier, there is already confusion surrounding CFLs. The negative views of CFLs will increase if people continue to obtain bulbs without guidance on how to use them properly.

An early development should be the production of clear leaflets to be given out with each CFL, so that they can be used effectively in people's existing fixtures.

This would enable another obstacle to be overcome: advice is not available at the point of purchase of a bulb since the majority of replacement bulbs are bought in supermarkets and retail staff there are unlikely to be well-informed about lighting issues. In addition, people are not used to, and possibly not aware of the need to ask for advice when purchasing light bulbs. A leaflet at the point of sale would help all consumers obtain a better understanding of the interaction between the bulb and the fixture, whether in their existing fixtures or in new purchases.

At the moment, it is not easy for householders to obtain a CFL on a trial basis and impossible to get expert advice in the home, where the fixtures are. Many German utilities have 'CFL test suitcases' which allow customers to try out a range of CFL types for free. An alternative approach to enable experimentation would be for retail outlets to offer 'no-questions' refunds if the bulbs were returned within a certain time period, encouraging people to try out the bulbs. A reliability 'quality list' for CFLs, as used in Denmark and Sweden, would also help provide consumers with confidence in the products.

9.6.1 The retail environment

Across the EU, 70% of households - over 100 million families - do not have a single CFL in the house. Those households that do have CFLs are having to teach themselves, by trial and error, how to identify which fixtures are most appropriate. Many of the participants in the technical survey stated how much they appreciated the opportunity to discuss with an expert how to obtain the best light from a CFL. At the same time, there are few articles in the media and magazines to inform the public on the lighting characteristics of different bulbs. It is not surprising that there is ignorance and confusion.

The difficult task is to see how such advice can be provided for householders. It may never be possible to provide detailed information to consumers when they purchase their low-energy bulbs in supermarkets. Educating householders will have to be achieved through other means. The obvious channel is through luminaire retailers, though the assistants may not always be well-informed at present. The recommendation is that:

The retail environment for luminaires is transformed into a showcase for low energy lighting.

This will require several policy initiatives, explained in more detail below, if consumers are to be provided with good quality advice:

- a label on a fixture to identify which bulbs can be used in it;
- a fully trained workforce, with incentives to understand and promote low-energy lighting;
- displays of fixtures that are suitable for CFLs.

A label for fixtures

There are no proposals in existence for a label on fixtures. The technical survey demonstrated that there are a large number of fixtures designed for incandescent bulbs that could not be considered suitable for CFLs. However, at the moment, there is no easy way for a consumer, when buying a fixture, to identify if it is suitable for use with integral ballast CFLs and which type of CFL would work best. Such information could be provided by a fixture label, corresponding to information given with the bulbs as to the type of fixtures they are suitable for. Thus, the fixture could be identified as suitable for, say, certain types of A rated bulbs. The criteria to qualify for the label should be simple and easy to apply. This process would encourage collaboration between the bulb and fixture industries, stimulating designs of incandescent fixtures suitable for integral ballast CFLs, with a natural progression towards dedicated luminaires.

Retail staff training and consumer support

The provision of labels on bulbs and fixtures is important for further policies, but the impact of the labels themselves depends upon the support provided in retail outlets. This is particularly true for lighting, where the efficiency of the system as a whole depends upon the efficiency of both the fixture and the bulb. The role of retail staff is particularly important in the promotion of dedicated fixtures, requiring an awareness of the additional benefits of these fixtures. The provision of training courses for the retail staff could be undertaken in conjunction with the light bulb manufacturers. A national accreditation scheme would make it possible to identify those shops where the staff are trained to a specified standard with regard to energy-efficient lighting.

Retail displays

One way of tackling several issues simultaneously would be for retail outlets with lighting showrooms to fit all - or the majority - of the fixtures on display with integral ballast CFLs. Ideally, this would be done in conjunction with a fixture label indicating suitability for CFLs and would serve several functions:

1. It would demonstrate to consumers that CFLs can work well in the similar fixtures they have at home, producing an appropriate light, thus bridging the gap between knowledge and experience. It would also guide them to the most suitable type of bulb to use with a particular fixture.
2. The retail staff would have practical examples to demonstrate the types of CFLs available and be more aware of the issues to consider when using them in fixtures originally designed for incandescent bulbs.
3. The retail outlets could make substantial savings in electricity as well as air conditioning, since the heat generated would be far less with CFLs.
4. Dedicated luminaires will gradually replace the incandescent fixtures currently on show as the range available increases.

A further extension of this would be to sell all fixtures with the appropriate integral ballast CFL already installed. In future, the householder could just replace the CFL with an identical bulb and would avoid the need to learn about some of the technical issues.

In combination with any approach designed to increase CFL ownership, appropriate disposal mechanisms need to be developed, to avoid mercury and phosphor pollution. While these may be in place in the commercial sector, such mechanisms are not readily accessible to the general public, in addition to which, many people are unaware of the need for careful disposal of old CFLs. A system whereby the used bulbs could be returned to the point of purchase, with a refundable deposit providing an incentive, could be effective (DEFU 1996) and again would get people into specialist lighting shops.

This suite of policies demonstrate ways in which the industries and policy makers could collaborate to ensure that people have access to good advice, particularly on how to use integral ballast CFLs in both fixtures in the home and new purchases.

9.7 INFLUENCING THE MARKET

9.7.1 Rebates and subsidies

It is not possible to identify the scale or scope of individual national rebate schemes that will ensure every household has a CFL. However, major national rebate schemes, funded by national government or the utilities, are an important part of the strategy and require careful targeting.

Rebates and subsidies for dedicated fixtures to increase their market share will be appropriate only once a range of fixtures is available. In the UK example explained above, there were both rebates for dedicated fixtures in the shop and retrofit programmes to get them installed in low-income homes. The latter would be less important in other countries, where few fixtures are part of the building fabric. Similarly, in certain countries, specification of dedicated fixtures in the building regulations could form part of the consolidation process as well as further guaranteeing future sales of pin-based bulbs.

9.7.2 Negotiating targets

In addition to rebates and subsidies, agreements to improve the efficiency of the average bulb sold by the manufacturers help to transform the market. These two policies are mutually supportive and increase the speed with which savings from lighting are achieved. The Corporate Average Bulb Efficiency (CABE) is proposed as such an agreement (Figure 9-3), designed to achieve several objectives (DECADE 1997, Hinnells 1997):

- to give a framework to the long-term structure of domestic lighting in Europe, with clearly defined targets. These provide the boundaries (maximum and minimum, depending on where the bulbs are installed) for future savings, as guidance for government in climate change negotiations;
- to provide a focus for the manufacturers of both bulbs and fixtures for new designs and production capacity;
- to establish a basis for discussions on a negotiated directive, rather than a voluntary agreement, if the role of imports are to be included;
- to provide wide flexibility and continuing customer choice over the types of bulbs on the market, even in 2020.

This agreement, negotiated with the light source manufacturers, would set a target level of efficiency for the average bulb sold, that improves annually. CABE allows flexibility in shifting from a majority of incandescent sales to a majority of more energy-efficient bulbs, while recognising that there will always be a certain level of incandescent and halogen sales. This approach has the scope to incorporate other efficient technologies which may emerge in the future, such as the 'future bulb' currently being developed through an

IEA procurement programme. In conjunction with a decision to phase out all integral ballast CFLs, this agreement would support the change to CFL dedicated fixtures. Collaboration between the bulb and fixture industries would enable bulb manufacturers to confirm that the appropriate dedicated fixtures are available in order that they may reach the targets set for CABE. A voluntary agreement by the lighting industries is the only way that has been identified to achieve the target set under the ETP scenario in a timescale that will contribute to the Kyoto commitments.

CABE is only an example for discussion. The opportunity exists to identify the contribution that the lighting industry can make to the reduction of carbon dioxide emissions. This is both a substantial challenge and a new perspective.

9.7.3 The role of manufacturers

The role of manufacturers is to ensure that the products are available in sufficient quantity and the role of retailers is to support the sales of these products with advice. The discussions on targets must include both sets of manufacturers, if the targets are to be met and manufacturing capacity is to be able to meet demand. If all households within the EU were to install four CFLs by the year 2002, this would require the annual production of over 420 million CFLs. Sales in Europe were only 120 million CFLs in 1997. However, sales have already doubled since 1993 and so this would appear achievable in terms of manufacturing capacity. Within this increase in production, there is a shift from integral ballast CFLs to CFLs for dedicated fixtures as the market for dedicated fixtures becomes more developed. Sales of pin-based CFLs currently represent 43% of world CFL sales and 50% of CFL sales in Western Europe, but these are mainly to the commercial sector.

Apart from the current production capacity, another issue is the reduced volume of sales in the longer-term, because of the longer life of bulbs. The domestic lighting is changing and will continue to evolve, whatever is the effect of additional policies to achieve greater energy conservation more quickly. The wider use of dedicated fixtures and electronic ballasts requires the light source manufacturers to become more involved with fixture production and the current manufacturers. It also opens up opportunities in the area of control systems. This could represent the next step in the development of lighting - once the bulb and fixture have become more integrated, lighting in the home can be treated as an overall system.

9.8 RECOMMENDATIONS

The key recommendations for transforming the lighting market are summarised here.

An inventory is made in each country of the CFL promotions that have already taken place and the lessons to be learnt from these. Information about known recipients will be collated, where possible. The objective is to ensure that every household has at least one CFL. Three particularly successful methods employed in the past have been:

- when a CFL is purchased, giving another for free;
- giving the CFL for free;
- purchasing the CFL through the electricity bill.

An early development should be the production of clear leaflets to be given out with each CFL, so that they can be used effectively in people's existing fixtures.

Establishing a 'quality list' for CFLs that have been tested for reliability.

The retail environment in specialist lighting shops is transformed into a showcase for low energy lighting, requiring several policy initiatives if consumers are to be provided with good quality advice:

- a label on a fixture to identify which bulbs can be used in it;
- a fully trained workforce, with incentives to understand and promote low-energy lighting;
- displays of fixtures that are suitable for CFLs.

Procurement of well-designed, dedicated fixtures, perhaps in conjunction with competitions, is needed as soon as possible. The resultant designs should be widely publicised in the media and provided with rebates initially. The rebate could be the inclusion of the appropriate bulb, for free.

Clear targets agreed with industry, for instance in the form of a Corporate Average Bulb Efficiency, to establish the direction for design and manufacturing capacity and confirm the electricity savings.

The lighting market is in the process of being transformed and this revolution will involve all the players: manufacturers, retailers and all 150 million households in the EU. The savings could be accessed rapidly, contributing to the demanding targets for carbon dioxide reductions in both 2005 and 2010 and long after. These savings would not be realised by the market alone and require positive policy intervention. All EU countries face a considerable challenge, as agreed at Kyoto, and want to set a positive example in future climate change negotiations. The opportunities available in domestic lighting could be used to develop some powerful common and co-ordinated actions.

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APPENDIX A: GLOSSARY

ballast - a device to provide the necessary circuit conditions to start and operate discharge light sources, such as fluorescent or high-intensity discharge (HID) lights. The ballast:

- provides proper conditions to establish an arc between the two electrodes;
- stabilises light output by regulating the electric current flowing through the bulb;
- supplies the correct voltage for proper operation of the light source and may compensate for voltage variations in the electrical current.

base - the end part of a light bulb containing the electrical contacts.

bayonet base CFL - a CFL with a ballast that has bayonet base that fits into the standard incandescent light bulb socket. A bayonet base CFL may be modular (see modular system) or self-ballasted (see integral ballast CFL). Both types are designed to replace standard incandescent light bulbs.

bulb - see light bulb

CFL - see compact fluorescent light bulbs.

colour rendering index (CRI) - (of a light source) a measure of the degree of colour shift objects undergo when illuminated by the light source as compared with the colour of those same objects when illuminated by a reference source of comparable colour temperature (Illuminating Engineering Society of North America - IESNA). To determine the CRI rating of a specific bulb, eight standard colour samples are illuminated by a reference source (defined as having a CRI of 100, with a similar colour temperature to the test source), and the test source. The “shifts” in colour appearance between the two sources are tabulated, and the results averaged to give a single CRI number for the test source.

colour temperature - (of a light source) the absolute temperature of a blackbody radiator having a chromaticity equal to that of the light source (IESNA). The colour temperature of the light source is measured in degrees Kelvin (K) and is a general measure of the ‘warmth’ or the ‘coolness’ of the emitted light. Light sources with a colour temperature below 3200 K are usually considered ‘warm’, while those above 4000 K are generally considered ‘cool’.

compact fluorescent light bulb (CFL) - a small fluorescent bulb, usually with one or more bends in the tube. These bulbs are operated by a magnetic or electronic ballast which is either incorporated with the bulb into a single unit (integral system) or is separate from the bulb (modular and dedicated systems).

current - a flow of electrical charge, measured in amperes or amps.

dedicated system - a CFL-ballast system where the ballast and socket for the CFL are permanently wired into the light fixture. The ballast may be located in the fixture or the wall plug.

dimmer - a device used to control the intensity of light from a luminaire by controlling the voltage or current available to it.

discharge light source - a light source which produces light by the passage of an electrical current through a vapour or gas.

efficacy - (of a light source) the total light output of a light source divided by the total bulb power input, expressed in lumens per watt. For fluorescent and high intensity discharge sources, the associated ballast wattage should be included in determining the system efficacy, as should any reductions in lumen output associated with the bulb-ballast combination.

efficiency - (of a luminaire) the ratio of luminous flux (lumens) emitted by a luminaire to that emitted by the light source used therein (IESNA). Luminous efficiency expresses the percentage of initial light source lumens that are ultimately emitted by the luminaire.

electronic ballast - a ballast which uses electronic circuitry to provide the voltage and current needed to start and to operate the light bulb. Electronic ballasts weigh less than magnetic ballasts and operate more quietly. Electronic ballasts operate bulbs at a higher frequency (20,000-60,000 cycles per second) than magnetic ballasts (60 cycles per second) which eliminates flicker and increases efficacy.

EESOP (Energy Efficiency Standards of Performance) - the UK Public Electricity Supply companies (PESs) are required by the Electricity Regulator (OFFER) to spend the equivalent of £1 per customer per year, during the period 1994-98, on the more efficient use of electricity. This amounts to a total investment of £100 million, 25% of which was originally targeted at electrical appliances in the domestic sector. However, less has been spent in practice since insufficient schemes were forthcoming. Most of the investment to date has been on lighting.

ETP (Economic and technical potential) - ETP is technically feasible *and* cost-effective to the consumer. Cost effective means it is the minimum life cycle cost (See life cycle cost). Feasible means it is proven technology. Other assumptions are average usage patterns, current EU prices for electricity, water and equipment, average market mark-ups and an 8% discount rate. If energy or equipment prices change significantly, or if new technologies become available, then the ETP may change. It does not include any reduction in consumption from changes in behaviour and so does not represent the technical limit or the lowest limit on consumption.

EU (European Union) - The EU was established by the Maastricht treaty and comprises the European Community (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, United Kingdom, Austria, Finland and Sweden), a Foreign Defence and Security Co-operation Mechanism and a Home Affairs and Justice Co-operation Mechanism.

filament - a fine wire heated electrically to incandescence in an electric incandescent light bulb.

fitting - see fixture.

fixed luminaire - a luminaire which is wired directly into the electrical circuit of a house and is operated by a switch on the wall. These are usually ceiling or wall fixtures.

fixture - the part of the luminaire which connects the light source to the power supply and is designed to distribute the light and position and protect the bulbs.

fluorescent light bulb - a discharge light source containing mercury under low pressure. An electric arc ionises the mercury, generating ultraviolet energy which, in turn, excites the inner phosphorus coating of the light bulb to fluoresce and emit visible light.

GLS (General Lighting Service) bulb - see incandescent light bulb.

glare - the sensation produced by brightness within the visual field that is sufficiently greater than the brightness to which the eyes are adapted to cause annoyance, discomfort or loss in visual performance and visibility (IESNA).

halogen incandescent light bulb - see tungsten halogen light bulb.

halogen torchiere - see torchiere.

high intensity discharge (HID) light source - a group of electrical discharge lights which operate at relatively high pressures (compared to fluorescent lights) and includes mercury vapour, metal halide and high-pressure sodium light sources.

high pressure sodium light source - a high intensity discharge light source in which visible light is produced by radiation from sodium vapour under high pressure.

incandescent light bulb - a bulb which produces visible radiant energy by the electrical resistance heating of a filament (also known as a general lighting service bulb or GLS).

incandescence - the self-emission of radiant energy in the visible spectrum due to the thermal excitation of atoms or molecules.

indirect lighting - light arriving at a point or surface after reflection from one or more surfaces (usually walls and/or ceilings) that are not part of the luminaire.

integral ballast CFL - a single unit including the light bulb and the magnetic or electronic ballast. The ballast has a screw or bayonet base that fits into a standard incandescent socket.

integral system - see integral ballast CFL.

IEA (International Energy Agency) - independent organisation of 24 Member countries, established within the framework of OECD to carry out a comprehensive and co-operative development programme for sustainable international energy trade.

kW (kilowatt) - one thousand watts.

kWh (kilowatt-hour) - measure of electrical energy consumed. One kilowatt-hour is equal to one thousand watts used for one hour.

lamp - commonly used to refer to portable luminaires such as desk, floor and table lamps. 'Lamp' is used in the USA instead of light bulb.

life cycle cost - the cost of the appliance to the consumer over the lifetime of the appliance (ie running costs as well as purchase price).

light - radiant energy is capable of exciting the retina and producing a visual sensation. The visible portion of the electromagnetic spectrum - the region where radiation is absorbed by the photoreceptors of the human visual system - extends from about 380 to about 770 nm. Light cannot be seen directly. It must be reflected or transmitted by an object and interpreted by the brain as a visual image.

light bulb - a generic term for a manufactured light source (sometimes referred to as a lamp) which includes the bulb, the base, and the internal structure which produces the light, either a filament or an arc tube.

lighting system - the set of equipment used to produce light, which includes the luminaire and the control device.

light source - the object that produces the light - a light bulb for electrical lighting.

low voltage light bulb - a bulb that operates at a low voltage, such as 6, 12 or 24 volts. A transformer must be used to convert the 220-240V supply to the lower voltage.

lumen - SI unit of luminous flux and is the time rate of flow of light, which expresses the total light output of a light source. The lumen rating can be considered as a measure of the summation of light output of a bulb in all directions. Ratings are determined and published by the light source manufacturer.

luminaire - generic term for a complete lighting unit consisting of a light bulb(s), parts designed to distribute light, to position and protect the bulbs and to connect the bulb to the power supply.

magnetic ballast - a ballast which uses a magnetic coil and capacitor, designed to limit the current and provide the necessary voltage and current to start and to operate fluorescent light bulbs. Magnetic ballasts are heavier than electronic ballasts.

mercury vapour light source - a high intensity discharge light bulb in which radiation from mercury vapour under relatively high pressure produces visible light.

metal halide light source - a high intensity discharge light bulb in which radiation from a mixture of metallic vapour and halides (eg sodium, thallium) produces visible light.

modular system - a CFL-ballast system where a pin-based CFL plugs into a separate ballast unit with a screw or bayonet base and can therefore be used as a direct replacement for GLS bulbs.

MtC - million tonnes of carbon. The carbon dioxide molecule contains atoms of both carbon and oxygen, as shown by its chemical formula CO₂. The weight of a molecule of carbon dioxide includes both the elements of carbon (atomic weight of 12) and oxygen (each of the two atoms has a weight of 16), to give a total of 44. The present convention is to refer to the carbon content only, so that the weight of a molecule of carbon dioxide is expressed in terms of carbon alone. To convert to million tonnes of CO₂, multiply by 12/44.

pin base CFL - a CFL with a base having two or four pins that requires a different socket to the standard incandescent screw or bayonet sockets. A pin base CFL is used in modular and dedicated systems.

portable luminaire - a free-standing luminaire which plugs into an electrical socket and is operated by a switch on the cable or fixture itself.

Reference Case (RC) - a projection of usage and ownership and the underlying rate of technical change determined from historical data where available. This was formerly known as the Business as Usual (BAU) scenario in previous DECADE reports.

recessed luminaire - a luminaire that is mounted above the ceiling (or behind a wall or other surface) with the opening of the luminaire flush with the surface.

screw base CFL - a CFL with a ballast that has an Edison screw base that fits into the standard incandescent light bulb socket. A screw base CFL may be modular (see modular system) or self-ballasted (see integral ballast CFL). Both types are designed to replace standard incandescent light bulbs.

shade - a device on a luminaire used to prevent glare (by hiding the light source from direct view), control light distribution and sometimes to diffuse or colour the light emitted.

socket - the part of the luminaire which electrically connects the fixture to the light bulb.

spectral power distribution (SPD) - (of a light source) a pictorial representation of the radiant power emitted by a light source at each wavelength or band of wavelengths in the visible region of the electromagnetic spectrum (360 to 770 nm). The SPD curve illustrates the distribution of power produced by the light source, at each wavelength across the spectrum.

spot light - a light source that provides a relatively narrow beam of light (eg of angle 12° or less).

switch - a device that turns a luminaire on and off by completing or interrupting the power supplied to the luminaire(s).

table lamp - a portable luminaire with a short stand, suitable for standing on furniture.

task lighting - lighting that is directed to a specific surface or area. Task lighting provides illumination for visual tasks.

torchiere - a luminaire providing indirect light in an upwards direction lighter indirect, typically a floor-standing fixture, often installed with a high-wattage tungsten halogen bulb.

tungsten halogen light bulb - a type of incandescent light source with the tungsten filament enclosed in halogen gas which reacts with the tungsten evaporated from the filament to re-deposit it on the filament. Halogen incandescents have higher efficacies than common incandescent light bulbs. They are sometimes referred to as quartz bulbs because the envelope is made from quartz glass.

UEC (unit energy consumption) - average annual energy consumption per household for a specific end use, such as lighting.

uplighter - a luminaire that directs light upward onto the ceiling and upper walls of a room, eg a torchiere.

watt (W) - unit of active electrical power - a measure of the rate at which electrical energy is used.

watt-hour (Wh) - unit of electrical energy. One watt-hour is the amount of energy consumed at the rate of one watt during a one hour period.

wattage - the active electrical power consumed by a light bulb or other electrical device.

APPENDIX B: PROJECT MEMBER PROFILES

Dr Brenda Boardman (Energy and Environment Programme Leader)

Brenda is programme leader for the Energy and Environment Programme of the Environmental Change Unit at Oxford University. She has been PowerGen Fellow in Energy Efficiency at St Hilda's College, Oxford since October 1991. She specialises in the efficient use of energy in the UK domestic sector, in particular the policy implications and problems faced by low-income households. She is acknowledged as the leading UK researcher on fuel poverty, and is responsible for the concept of affordable warmth. She has published widely and is regularly called upon for expert contributions to conferences, specialist workshops and the UK media. In addition to managing the DECADE project (Domestic Energy and Carbon Dioxide Emissions), she has overall responsibility for the Programme's research for the European Commission and the Department of the Environment, Transport and the Regions, and for research on rural transport.

Harriet Griffin

Harriet has a background in Zoology and gained an MPhil from the University of St Andrews where she studied the role of wild bees in crop pollination. Before joining the ECU, where she contributes towards the analysis of trends in appliance ownership and use, she worked for the Agriculture Development Advisory Service.

Dr. Willi Herbert

Willi has been with the Research Association for Environmentally Sound Energy Conversion and Use Ltd. (RAESCU) (*oder: Forschungsgesellschaft für umweltschonende Energieumwandlung und -nutzung mbH*) as Senior Researcher and project manager since 1992 and is Head of the Unit for Energy Policy and Communication of the Energy Foundation (*oder: Energiestiftung*) Schleswig-Holstein since 1998. He has a background in Sociology, Political Science and Administrative Sciences. His actual main working fields are the development and evaluation of energy policy and energy policy instruments and the analysis of social and organisational determinants of energy consumption. He has published widely and is an invited speaker at national and international conferences.

Dr Mark Hinnells

Mark is responsible for analyses of technical trends in appliances and contributes to policy analysis for market transformation. He is leading the ECU's collaboration on efficiency of domestic electric storage water heaters and represented the ECU on the EU Group for Efficient Appliances study of washing machines, dishwashers and dryers. He has a background in Industrial Design with a Masters Degree from Manchester Metropolitan University and his PhD was on 'Evaluation of environmental impacts of domestic appliances and implications for public policy'.

Dr Kevin Lane

Kevin is responsible for developing the DECADE model, and applying it to policy analyses for EU working groups. He represented the ECU on the EU working group on standby consumption in televisions and videos and on the GEA 'wet' study. With a first degree in digital systems and microprocessor engineering, his doctoral research at Lancaster University was on the development and application of non-stationary time series analysis techniques to climatological data. His final project before joining the ECU was the development of the Derwent Water Resources Model (a computer based management model) for the National Rivers Authority. He was awarded jointly the World Meteorological Organisation's 1996 Norbert Gerbier Prize.

Susanne Lörx

Susanne has been with RAESCU as Researcher and Project Manager since 1993 and was in the same position with the Energy Foundation Schleswig-Holstein in 1998. She has a background in Social Sciences and Evaluation Research. She has done the evaluation of local energy conservation programmes including the active participation of administration and inhabitants. She just finished (in collaboration with Kai Schuster) RAESCU's contribution to the evaluation (co-ordinated by the Wuppertal Institute) of the most recent and extended CFL campaign in Germany.

Dr. Tihomir Morovic

Tihomir has been Managing Director of RAESCU since 1990 and is Head of the Research Unit of the Energy Foundation Schleswig-Holstein since 1998. He has an Inauguration in Physics. He did a forecast on energy consumption up to 2010 and is an expert for the use of renewable energies. His actual main working fields include the analysis of the energy policy programmes in the Baltic region where he gained a lot of experiences with the execution of EC financed projects. He has published widely, is an invited speaker at

national and international conferences and has been advisor to State Government and utilities on matters of energy conservation.

Jane Palmer

Jane graduated with an honours degree in Natural Sciences from Cambridge University and has a background in genetics. Jane joined the Energy and Environment team at the Environmental Change Unit, Oxford in July 1995 and worked on the analysis of ownership, stock profile and usage data for the DECADE model as well as being responsible for collecting and analysing the lighting data.

Agneta Persson (MSc)

Agneta is Head of Division of Energy Efficiency and Technology Procurement in the Domestic and Commercial Sector at the Swedish National Energy Administration. Agneta is one of the leading persons behind developing technology procurement in the field of energy efficiency. Agneta has also for many years been a keen mover towards energy efficiency in the domestic and commercial area, being the organiser and Conference Manager of the first European Conference on Energy-Efficient Lighting in 1991, and the ECEEE 1995 Summer Study. Her contribution has made these conferences, and networks to a valuable place for policy makers and energy efficiency researchers to meet. She holds a Masters Degree in Civil Engineering from Chalmers University of Technology, Gothenburg. She has published widely and is an invited speaker at national and international conferences.

John Rathbone

John has an MA in geography from Edinburgh University and is completing a DPhil thesis on the influence of weather on asthma admissions in the Oxford region. He has devised and taught an undergraduate course on database management and has lectured in geographical and epidemiological techniques.

Kai Schuster

Kai has been with RAESCU as Researcher and Project Manager since 1995 and is in the same position with the Energy Foundation Schleswig-Holstein since 1998. He has a background in Ecological and Motivational Psychology and Social Marketing. His current interests are the human aspects of energy use and the organisation of local climate protection policy. He just finished (in collaboration with Susanne Lörx) RAESCU's contribution to the evaluation of the most recent and extended CFL campaign in Germany.

Heini-Marja Suvilehto (BA)

Heini-Marja joined the Swedish National Energy Administration in 1994 as a member of the team developing the Effect Chain Analysis Method (a new, radically more reliable method for assessing market transformation actions and measures). She has performed analysis and in-depth studies of the potentials and dissemination of energy efficiency measures. Heini-Marja holds a Bachelors Degree in Political Economy from the University of Stockholm. She has participated in several international projects on improving data on energy efficiency.

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