DELight

Energy and Environment Programme
Environmental Change Unit
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Domestic Efficient Lighting

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The main findings and conclusions are provided in this Final Report. Additional research is described in the Supporting Material. Both publications are available from each of the partners, or direct from the ECU (address on back cover).

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EXECUTIVE SUMMARY

By 2020, 43% of residential lighting electricity consumption in the EU could be saved through identifiable policy actions. This report demonstrates how such savings could be achieved.

Electric lighting is used in practically all households throughout Europe and represents a key component of peak electricity demand in many countries. There is already a well developed energy-efficient technology available on the market, in the form of compact fluorescent light bulbs (CFLs), that could deliver substantial savings. Such savings could be accessed quickly due to the rapid turnover of light bulbs in the stock - the challenge is to get the more efficient technology installed and guarantee the savings. No other changes in consumer behaviour are necessary. The agreement (still to be ratified) reached during the Climate Change Convention at Kyoto in December 1997 was for targets to reduce CO_2 emissions to be ‘legally binding’. This requires greater confidence and certainty that any potential savings will be achieved. Lighting represents an area of potentially large, rapid and guaranteed energy savings that could usefully contribute to these challenging international objectives.

The DELight project incorporates data on domestic lighting from all over Europe, focusing on the EU, with in-depth analysis of three countries: Germany, Sweden and the UK. These three countries account for 40% of households and almost half of all domestic electricity consumed in the EU. Spain was also included in one part of the detailed studies to represent countries in Southern Europe. This is the first time such detailed information on residential lighting in Europe has been brought together. Previously data were sparse and coverage is still inadequate, but evidence in this study demonstrates that domestic lighting is of greater importance than present policies have recognised, both in magnitude and energy savings potential.

The particular focus of this study has been to combine information on both the bulb and the light fixture. Research on the potential energy savings from changing the bulb alone results in optimistic and inaccurate estimates: the aesthetics of lighting are crucially important and the existing fixtures in homes are a major constraint that has to be recognised.

THE LIGHTING PICTURE

- Total domestic lighting consumption in the 15 EU Member States is at least 86 TWh (17% of all residential electricity use) and expected to rise to 102 TWh by 2020, largely because of the growth in household numbers.

- At the national level, average household lighting consumption ranges from 240 kWh pa to 920 kWh pa across Europe. However, the majority of these figures are simple estimates and without more reliable figures, the true importance of this sector can not be confirmed.

- Detailed modelling of lighting consumption for Germany and the UK reveals electricity use to be far higher than previously thought - at least double prior estimates in both countries.

- Lighting electricity use is dependent on a number of factors, such as size of house (m^2), number of inhabitants and income. The relative importance of each has not been established.

- The average number of light bulbs is 24 per house across the EU. The majority (at least 70%) are incandescents, with the remainder being fluorescents (strip or CFLs) and halogens. In Germany and Sweden, there are more halogens than CFLs in the stock.

- The light source manufacturing industry is dominated by three multi-national companies, common to both the residential and commercial sectors, whereas light fixtures are manufactured by over 1000 companies in the EU, often specific to the residential sector. Far Eastern imports are increasing in both markets.

- Successful collaboration between these two disparate industries has been demonstrated by the rapid development of the market for halogen bulbs, which require specific fixtures.

- The lighting retail market is split, with most consumers habitually purchasing bulbs in supermarkets, where fixtures are not available. Most fixtures are bought in specialist lighting shops or DIY stores.

- One new fixture is bought by the average household annually, as either a replacement or an additional item.

- Fixtures can be viewed as personal possessions and taken when moving house or may be treated as part of the building fabric, varying from country to country.

- Expenditure on lighting in the EU is 10.3 bn ecu on electricity, with a further 5 bn on fixtures in 1995. The value of the bulbs is not included.

- There is growing interest in the use of lighting in the home, illustrated by the popularity of torchiere uplighters (using high wattage halogens) and an expected trend towards increasing numbers of fixtures. Without intervention, this is likely to increase lighting electricity use, but also represents an opportunity for the installation of more energy-efficient lighting.

OPPORTUNITIES FOR SAVINGS

Compact fluorescent light bulbs (CFLs) use at least 60% less electricity than the traditional incandescents while lasting ten to twelve times as long and can therefore deliver substantial savings in terms of both electricity and money. Their long life means they need replacing less often and so are particularly suitable for use in inaccessible fixtures or for elderly or disabled people. Integral ballast CFLs, with a screw or bayonet base, currently represent the best opportunity to achieve significant electricity savings in residential lighting since they are the most energy-efficient technology suitable for use in fixtures already in the home. Pin-based CFLs are also available. These have a separate ballast either in a screw or bayonet based adapter (modular system) or incorporated into the fixture (dedicated system).

Ownership of CFLs is still relatively low, with consumer ignorance and confusion preventing wider use. Many of the problems associated with the use of these bulbs in the existing fixtures could be avoided through the use of fixtures designed for pin-based CFLs. Dedicated fixtures optimise the light distribution and performance of CFLs and improve the cost-effectiveness of installation (pin-based CFLs are cheaper than the integral ballast versions), as well as guaranteeing the savings and future bulb market. While dedicated fixtures are common in the commercial sector, there is a lack of suitably designed fixtures for the residential sector, representing an energy-saving opportunity that has not yet been fully exploited.

- Only 30% of households in the EU currently have at least one CFL, with those households that own them having an average of three or four.

- Three to four CFLs per owning household appears to be a stage in the development of residential lighting - a higher level of ownership is possible. People who are happy with their existing CFLs are unlikely to switch back to incandescent bulbs in these fixtures.

- Across Europe, the main advantages of CFLs are seen as environmental or lower running costs.

- The Spanish purchase CFLs predominantly for their bright light, which is particularly valued in Southern Europe.

- Ownership of CFLs is highest in those countries with the lowest price of CFLs relative to GLS (general lighting service) bulbs. These tend to be the countries where there have been a number of high profile CFL campaigns, such as Denmark and the Netherlands.

- Experience of CFLs, through using them in the home, doubles the proportion of people who view them positively.

- Two-thirds of CFL owners consider that CFLs provide a suitable light for all activities. A similar proportion believe that CFLs do not fit in all their fixtures. The constraint for these households is seen as the fixture, not the bulb.

- When a wide range of CFLs were demonstrated in the home by a lighting expert, the householder agreed that at least 40% of their fixtures, without alteration, were suitable for CFLs. This is an average of eight bulbs. There was almost complete agreement between the professional and the householder on what was deemed ‘acceptable’.

- Wall and ceiling fixtures were more suitable for use with CFLs than table or floor-standing luminaires.

- Replacing the four most highly-used bulbs, in fixtures identified as suitable, would save around 200 kWh, worth 24 ecu pa per household in electricity savings. This represents over a quarter of the electricity consumed by domestic lighting in Germany, Sweden and the UK.

BARRIERS TO BE OVERCOME

- The main reasons for not owning CFLs were that they were too expensive or the householder had never considered purchasing one. Ignorance and uncertainty were more important reasons for non-ownership than dislike of the bulb or the quality of light. Even current owners of CFLs need assistance in recognising the opportunities for installing CFLs in their fixtures.

- Consumers lack confidence in the durability and continuity of CFL technology. The range of CFLs on the market is confusing and they do not know how to choose the appropriate one for their fixtures. There are limited opportunities for trying out CFLs at present.

- The present retail structure for bulbs and fixtures and the lack of informed retail staff is preventing the education of the public on how to use CFLs correctly in the fixtures in the home.

- There is little collaboration between the bulb and fixture manufacturers in developing a range of well-designed fixtures suitable for CFL use in the residential sector, so the annual purchase of a new fixture is likely to add to the stock of inappropriate fixtures.

THE WAY FORWARD

It has taken a considerable number of promotions and rebate schemes to get the first 135 million CFLs into European homes, partly because of their high price. Increasing ownership further will need a continuing level of policy support. However, if the full savings available in this sector are to be realised, a coherent strategy is required to transform the lighting market. Market transformation is a well established strategic approach, utilising a combination of policies, such as education, labels, rebates, procurement and standards, to speed up the introduction of energy efficient technologies into the home. This approach is currently less well developed with domestic lighting than with appliances.

The market for dedicated fixtures needs to be developed now, through collaboration between the manufacturers, to ensure the availability of a sufficient range of suitable fixtures within the next five years. In parallel with this, promotion of integral ballast CFLs needs to be continued in the short term because of the current lack of dedicated fixtures. The underlying aim of any approach must be to build a positive image of CFLs to lay the foundation for the successful transfer to dedicated fixtures.

- The initial objective is to get a CFL into every home, so that households can experience this type of light and establish where and how they would like to use it.

- The ultimate aim of any market transformation strategy for lighting must be for the majority of fixtures in the home to be dedicated to more energy efficient light sources.

- The constraint in the short term will be manufacturing capacity and consumer confidence. In the longer-term, it is essential to transform the fixture market.

RECOMMENDATIONS FOR BUILDING A POSITIVE IMAGE

- Attractive, well-designed dedicated fixtures could be developed through procurement or competitions to widen consumer choice.

- Free or heavily subsidised CFLs is the most effective way of getting the first of these bulbs into the 70% of homes currently without one, this should be accompanied by an explanatory leaflet.

- The quality of CFL products on the market needs to be guaranteed, with continuity and compatibility of technologies. The Energy Label provides a good basis for this, possibly in combination with a ‘quality list’ of CFLs as used in Denmark and Sweden.

- People should have the opportunity to try out CFLs, either through test samples or with a guaranteed refund.
- Appropriate mechanisms need to be put in place for the safe disposal of fluorescent bulbs to prevent pollution from mercury and phosphors.
- Transforming the fixture retail sector would enable consumers to obtain clear information and advice on the appropriate use of CFLs. An accreditation scheme would identify shops with trained staff.
- A ‘suitability label’ on fixtures would enable consumers to identify the appropriate CFL to use.
- Retail outlets could use CFLs in the existing fixture displays, demonstrating their correct application and raising awareness among both retailers and consumers.
- An EU Corporate Average Bulb Efficiency standard (CABE) is one possibility: a negotiated agreement requiring a certain efficiency of the average bulb sold, with improvements each year. This would combine flexibility with guaranteed savings and support the long-term strategy.

The switch from incandescents to CFLs is as revolutionary as the switch from gas to electricity in domestic lighting 70 years ago and needs to be recognised as such. The role of suitable fixtures is of similar importance.

CHAPTER 1: INTRODUCTION

This report presents the main findings from the DELight project, an investigation into the realistic level of savings available in domestic lighting, given the constraints of the market, the technologies and the aesthetics of lighting. Full details on the work undertaken can be found in the Supporting Material (available on request from the ECU).

Domestic lighting is an area which has been poorly studied across the whole of Europe. The lack of information in this area is surprising considering how ubiquitous electric lighting is throughout European households.

Lighting is a complex area. Not only is it a necessity to be able to see by, but lighting also has strong cultural significance. It plays an important role in decorating the home and creating an atmosphere - lighting has been described as the 'jewellery of architecture'. Such factors will determine the type of light people have in their homes and the way in which they use it, as well as the energy savings accessible in this sector.

For most countries, only rough estimates for the amount of electricity consumed by the lights in people's homes are available. Before this study was undertaken, there were no estimates for domestic lighting consumption across the whole of the EU. In the UK, prior to the DECADE study, figures quoted for domestic lighting consumption were found to underestimate actual consumption by almost 50% (Palmer 1997, DECADE 1995). Without a reliable base line, it is impossible to identify the magnitude of savings that could be made in this sector and to evaluate what savings might already have been made. Only through a better understanding of domestic lighting will it be possible to identify the policies, both at the national and European Union (EU) level, that will secure reductions in energy use.

Lighting is an area where electricity savings could be made relatively quickly and cheaply. Light bulbs are a frequent purchase and a technology that could enable such savings to be made is already on the market in the form of compact fluorescent light bulbs (CFLs). That is not to say that this is the only technology that is worth pursuing, but this is the best currently available.

Why are savings needed? The discussions at the Climate Change Convention at Kyoto in December 1997 resulted in the agreement that the targets set should be 'legally binding', which means essentially that national governments have to guarantee these savings. Such targets centre around the need to reduce the level of CO_2 emissions. The extent to which this is an important issue for any one country depends on the electricity generating mix of that particular country. However, electricity savings may still be important for other reasons, such as the phasing out of the nuclear power stations, as is the case in Sweden. Lighting is also a key component of peak demand in many countries, which may also be a strong motive for reducing demand in this sector.

1.1 LIGHTING POLICIES

Much progress has been made at the European level for energy-saving policies on domestic appliances since the introduction of the Framework Directive 92/75/EEC on energy labelling, in 1992. The domestic appliance market has adjusted to such legislation, accepting further legislation on efficiency standards for cold appliances (refrigerators, fridge-freezers and freezers) and voluntary agreements for both the wet (washing machines and tumble dryers) and brown (TVs and VCRs) markets. However, policies affecting the domestic lighting market have not be so forthcoming. The lighting industry is complex, being a combination of two technologies, the bulbs and the fixture, which have two quite different market structures.

The only two policies currently in place for domestic lighting at the European level apply to light sources. These are an Energy Label on light bulbs due to come into force in the year 1999 (although not mandatory until 2001) and a negotiated directive on energy-efficiency classes for fluorescent bulb-ballast systems, providing the basis for removal of inefficient systems from the market. Other programmes at the European level include the International Energy Agency (IEA) procurement programme on a replacement incandescent light bulb (RIL), also known as the 'future bulb', which would lie somewhere between a standard incandescent bulb and a CFL in terms of energy efficiency.

At a national level, most policies have, again, focused on bulbs rather than fixtures. Almost all European countries have undertaken some type of lighting campaign, often run by the utilities. The key motivation for utilities to become involved with such programmes is to reduce peak demand, since domestic lighting often represents a key component of peak load. However, it is not clear how involvement in these programmes will be affected by the liberalisation of the electricity supply industries across Europe. Experience gained through past policies can inform future policy, as discussed in Chapter 9.

1.2 WHY THIS STUDY?

Given the lack of information available on domestic lighting, there was an obvious need for a start to be made in this area, particularly given the important role this sector has in achieving the emissions targets agreed at Kyoto.

The original key aims of this project were to undertake:

- Market analysis (both historical and projected) for national and EU market transformation policies for domestic lighting, including luminaires and lamps,
- A more detailed analysis of the market, technology, behaviour and barriers to increased efficiency for three countries in particular, and
- To establish the criteria for an EU Appliance network (this is covered in a separate publication).

Previous studies on lighting have focused on light bulbs, without considering the role of the fixture. Since it is the interaction between the light source and the fixture which results in the quality and distribution of light provided by the luminaire, it is important to consider these two technologies together rather than as separate entities. The aesthetics of lighting are another important consideration if energy-efficient lighting is to be successful. DELight has focused more on the role played by the fixture, both those already installed in the home and the need for fixtures which are specific to energy efficient light sources, providing a realistic assessment of the potential for savings in this area. Most of the research has centred around CFLs and obstacles to their installation, since this is currently the energy-efficient technology most suitable for the residential sector. However, much of the discussion is relevant to the problems that need to be tackled for any replacement for the traditional incandescent bulb.

CHAPTER 2: TECHNOLOGIES

Electric lighting did not become common in European homes until around the 1930s, although the first carbon filament light bulb was patented by Edison in 1879. When first introduced, electric lighting was promoted for its health advantages over gas, being a clean, safe alternative. However, it was considered to be harsh and less ‘kind’ than previous light sources and some homes were apparently reluctant to lose the heat benefit from the gas flame (Rudge 1997). Light source manufacturers produced booklets to advise people on how to use this new technology, with guidelines on where to use lights for specific tasks. Electric light was considered a luxury, incandescent bulbs being an expensive commodity. In the UK, the lighting electricity tariff was also higher than that charged for other electricity uses.

From when it first appeared on the residential market, the incandescent GLS (general lighting service) bulb was recommended for its comfort and colour attributes and has remained the dominant technology ever since. Efficacy of this technology has improved over the past 60 years, from 3 lumens/Watt to an average of 12 lumens/Watt today (Starby 1992, Davis *et al* 1993), but over 90% of the electricity used by an incandescent bulb is still lost as heat. The Edison screw base was standardised in the USA when the production process was first mechanised at the end of the nineteenth century and this type is found in most countries today. However, the bayonet cap has remained in use in UK households since it was introduced by the Edison and Swan company in 1884 (Rudge 1997). With further advances in the manufacturing processes, the GLS bulb is now the cheapest light source available, in contrast to the early high prices. Manufacturers have concentrated on extending the range of different types on offer, with a wide variety of wattages, colours and sizes currently available. Tungsten halogen bulbs first appeared on the market in 1959 and represent an improvement in incandescent technology with better efficacy and quality of light, as well as longer bulb life.

Fluorescent strip lighting was introduced into European households in the 1940s, but the ‘cooler’ light produced by these bulbs has meant that its application has been limited, being used mainly in kitchens. Compared to incandescent bulbs, there have been huge advances made in fluorescent technologies, with improvements in the quality of light as well as continual increases in efficiency and decreases in tube size - both diameter and length. A further development of this technology resulted in the production of compact fluorescent lights (CFLs) in the early 1980s - these are essentially folded fluorescent tubes.

In terms of the history of light fixtures, the early electric bulbs were used in the existing light fixtures that had been installed as oil or gas lamps. However, manufacturers recommended the use of specially designed fixtures for a more satisfactory result. Many early fixture designs imitated the traditional light forms such as candles or gas lamps and bulbs in the shape of a candle flame are still popular today. As incandescent bulbs were improved and became brighter, it became desirable to shade the bulbs rather than leaving them bare. Indirect lighting and the use of a variety of light points to avoid monotony was recommended as early as 1926 (Rudge 1997). In UK households, there is normally a single central light point in the middle of the ceiling and the possibilities for extra lighting are limited by the number of electric sockets available.

The advent of electric lighting in homes has altered the way in which people use space and time. They are no longer restricted by limited light sources or the hours of daylight, leading to substantial changes in the way in which people lead their lives (Garnert 1993). The use of incandescent bulbs in the majority of households throughout Europe provides both the light source and light fixture manufacturers with a guaranteed market. Demand from consumers for an incandescent replacement is low. Hence, there is little incentive as yet for the lighting industry to take up new ideas and developments (Rudge 1997).

2.1 LIGHT SOURCES

The basic light sources available on the European residential market do not vary widely between countries. A brief overview is given here to highlight some of the issues relevant to changing to more energy-efficient lighting, providing the context for the later discussions. There may be slight differences in terms of wattage and colour of bulbs sold in each country, but the characteristics of each type of light source are essentially the same. These light sources can be classified into five general categories, as summarised in Table 2-1. It is not appropriate here to give an exhaustive list covering the full range of different bulbs within in each category; the table is intended to provide a broad comparison between the different types and hence uses average figures. Much of the following technical information has been obtained from the E Source Lighting Technology Atlas (Audin *et al* 1994) and the lighting catalogues of Philips and Osram. More detail is provided in Chapter 3 of the Supporting Material.

Table 2-1 Basic properties of the key domestic light sources

Light source	Bulb wattage [W]	Efficacy [lm/W]	Length [mm]	CRI	CCT [K]	Average life [h]	Ballast required	Dimmable
Incandescent								
GLS	15-150	6-18	90-120	95+	2800	750-1500	No	Yes
Low voltage halogen	15-65	8-20	40-60	95+	3000	2000-4000	No Requires transformer	Yes
High voltage halogen	75-500	13-29	85-115	95+	3000	2000	No	Yes
Fluorescent								
Fluorescent strips	4-58	65-100	150-1500 Ø 7-40	51-95	2800-6500	10 000-20 000	Yes	Some
CFL	5-36	42-82	85-215 Ø 12.5-17.5	82-85	2700 - 4000	10 000 - 12 000	Yes	Some

***Notes** (technical definitions appear in the glossary):*
GLS - General Lighting Service
Efficacy - a measure of the light provided (measured in lumens, lm) per unit of input power (Watts). The higher this is, the more efficient the light source.
Ø - fluorescent tube diameter
CRI (Colour Rendering Index) - this has a maximum value of 100. The higher the CRI, the 'better' the colour of illuminated objects appear.
CCT (Correlated Colour Temperature) - the higher the CT, the 'cooler' the light appears.
Average life - number of hours after which, on average, 50% of bulbs will have failed

2.1.1 Incandescent light sources

GLS incandescent bulbs are the most commonly used light source in the residential sector - people are familiar with the technology, the bulbs are cheap and easy to use, have good colour rendering properties and can be dimmed. The majority of European households use screw-based GLS bulbs, with bayonet-based bulbs confined to the public and commercial sectors. However, in British and Irish households, bayonet-based bulbs are common. GLS bulbs are the least efficient light source with low efficacy and short operating life. Their life span can be extended by operating at reduced voltage, although this results in lower efficacy. Conversely, using a higher voltage will reduce the average life of the bulb: operating a 240V incandescent at 250V can reduce average life expectancy by 57% (Starby 1992). GLS bulbs emit light of approximately uniform intensity in all directions.

Halogen bulbs represent an improvement on GLS bulbs - the technology is essentially the same but with the filament enclosed in halogen gases. This extends the life of the filament and improves both efficacy and light output although long periods of dimming will reduce bulb life. Halogen infrared-reflecting (HIR) bulbs have an even higher efficacy due to a special coating within the bulb that reflects infrared radiation back onto the filament, resulting in a higher filament temperature. Screw and bayonet based halogens are available, but the majority are pin-based and so require specially designed fixtures. Low-voltage halogens operate at 12Vor 24V and therefore require a transformer, either magnetic or electronic, which uses additional power - around 10 to

20% of the bulb wattage. Operating at low-voltage has the advantage of allowing the use of smaller filaments, giving smaller bulbs with tighter beam control. The use of reflectors in these bulbs produce a focused beam of light in one direction. This type of halogen is often used for display and accent lighting and is popular in the commercial sector. High-voltage halogens are non-directional light sources commonly used in halogen torchieres - these are inexpensive uplighters, typically using 300-500W halogen bulbs, providing a bright, indirect and diffuse light.

A further development in incandescent technology is being encouraged through the International Energy Agency (IEA) technology procurement competition for a replacement incandescent bulb - the ‘future bulb’. The specification requires a bulb which is 30% more efficient than current incandescents and lasts around three times as long (Davidson and Borg 1997). It is unlikely that the winning bulb will be available on the market before 2001, since the call for bids has recently been reissued (Davidson 1997).

2.1.2 Fluorescent light sources

The two main classes of fluorescent light sources used in the residential sector are strip lights and CFLs. These are both based on the same technology (CFLs being essentially a folded fluorescent tube) which is different and more complex compared to incandescent bulbs and is also more efficient. Fluorescent light sources require a ballast to function, the type of ballast used (magnetic, electronic or a hybrid) being a primary determinant of bulb efficacy. Increased efficacy is also associated with longer length and smaller diameter tubes. They give a linear diffuse light emitted from the entire surface of the tube, unlike the point source of an incandescent filament. The type of phosphor used to coat the walls of the tube determines light quality. Advances in phosphor technology have led to improvements in fluorescent light quality over the years, with a wide range of bulbs of different Colour Rendering Indexes (CRI) available today. Fluorescent lights last around ten times as long as incandescent bulbs, although those operated by magnetic ballasts are more sensitive to switching than those with electronic ballasts - their lifetime is dependent on the number of times they are started and the length of time they are then used. Average lifetime figures are usually quoted on the basis of three hour cycles per start (three hours on, twenty minutes off). Switching cycles of less than three hours will result in decreased lifetime due to erosion of the cathode. Recent tests have found high quality electronically ballasted products to be unaffected by frequent switching (Pedersen 1997, Stiftung Warentest 1995).

CFLs are smaller and more compact than full sized strip lights, due to folding of the tube, which is also narrower and shorter. The narrow diameter makes it economical to use high-quality phosphors, which give good colour rendering and high efficacy. The patent on the particular phosphor used in CFLs has recently expired, which may result in improvements in the light quality of cheaper bulbs. CFLs are generally of lower efficacy than strip lights, since the folds in the tube shade the light output in places, but they still represent around a four fold improvement on incandescent efficacy (Table 2-1).

There are three main classes of CFLs: integral units, modular units and dedicated systems. Dedicated systems are the only type to include the fixture. Integral units are those where the ballast and CFL are incorporated into a single assembly. These are intended for use in fixtures designed to take standard incandescent bulbs and so have a screw or bayonet base. Modular and dedicated systems use pin based CFLs, with two or four pins, which plug into a separate ballast (modular) or directly into a fixture incorporating the ballast, either in the actual fixture or in the plug (dedicated). Integral units are dominant in the residential sector at present. The CFL bulbs used in any of these systems are available in a wide range of shapes and sizes, the main types being two, three or four finger (with the tubes sometimes folded), 2-D and circline. The major manufacturers, such as Philips and Osram, are starting to produce CFLs enclosed within a glass envelope, giving it an appearance similar to that of a traditional incandescent bulb. These bulbs have a lower light output and a shorter life (around 5-6000 hours) than standard CFLs (Borg 1997).

CFL efficacy varies widely with wattage, phosphor, ballast type and ballast quality. Higher wattage CFLs and those operating on electronic ballasts tend to be more efficient. Most early CFLs used magnetic ballasts, typically heavier and less efficient than their electronic counterparts. Flicker, hum and long start up times are also associated with magnetic ballasts. Electronic ballasts are now more common and suffer from fewer drawbacks, being silent, lighter-weight and more efficient. These systems are often ‘instant start’ which means the bulb will light up immediately, although it may still take up to three minutes to reach full light output. Certain electronic ballasts also allow dimming of CFLs, but these are expensive and only operate with four pin bulbs at present. Dimmed light from a CFL tends to be bluish, rather than reddish (as with incandescents), which may not be the desired effect (Frantzell pers comm 1997).

It is easier to direct the light from a CFL than from a strip light, although the light from a CFL has an asymmetric intensity distribution, unlike the uniform light distribution from a standard incandescent bulb.

The distribution also varies along the axial and radial axes and differs with the shape and type of CFL. This is an important factor to consider when selecting an appropriate luminaire for a CFL to ensure that the light distribution is optimised. Other considerations are bulb orientation and temperature. Standard CFLs operate best in a base up (ie with tube downwards) position - light output decreases by up to 13% in a base down position, although this varies between different bulb types. Lifetime and output are affected by extremes of temperature. Sensitivity to these two factors is reduced in amalgam CFLs that have had certain alloys added to the mercury. Philips have used this type of CFL in their new enclosed 'pear-shaped' version.

2.1.3 Economics of CFLs

A primary reason for using CFLs is the savings that can be achieved in terms of energy and running costs, which benefit both the householder and society as a whole. Due to their higher efficacy, a 15W CFL can provide the equivalent light output to a 60W incandescent bulb. This represents a reduction in wattage of over 75%. A CFL also lasts around ten times as long as an incandescent. The high initial cost of a CFL, currently around 10-20 times the price of an incandescent bulb, can be paid back rapidly through the resultant energy savings and avoided cost of replacement incandescent bulbs. The actual length of the pay back period is dependent on the annual operating hours as well as the relative bulb prices and the cost of electricity. A three to one ratio for the replacement CFL wattage has been assumed in the cost-effectiveness calculation to allow for manufacturers over-rating CFL performance, as has happened in the past (see Section 2.1.4). This gives a conservative estimate for the cost-effectiveness of CFLs - the pay back periods will be even shorter if the more usual four to one ratio is used (ie replacing a 60W GLS bulb with a 15W CFL). Assuming an average price of 14 ecu for a CFL, 0.7 ecu for a GLS bulb and 0.12 ecu/kWh for electricity (based on the country profiles in Chapter 4), a 20W CFL replacing a 60W GLS bulb used for 3.5 hours a day will have a simple pay back of 2 years (Figure 2-1). With a lower price of 5 ecu for a CFL, representing either a pin-based CFL or a further decrease in the cost of an integral ballast CFL, it becomes cost effective to install CFLs in locations used only for an hour a day.

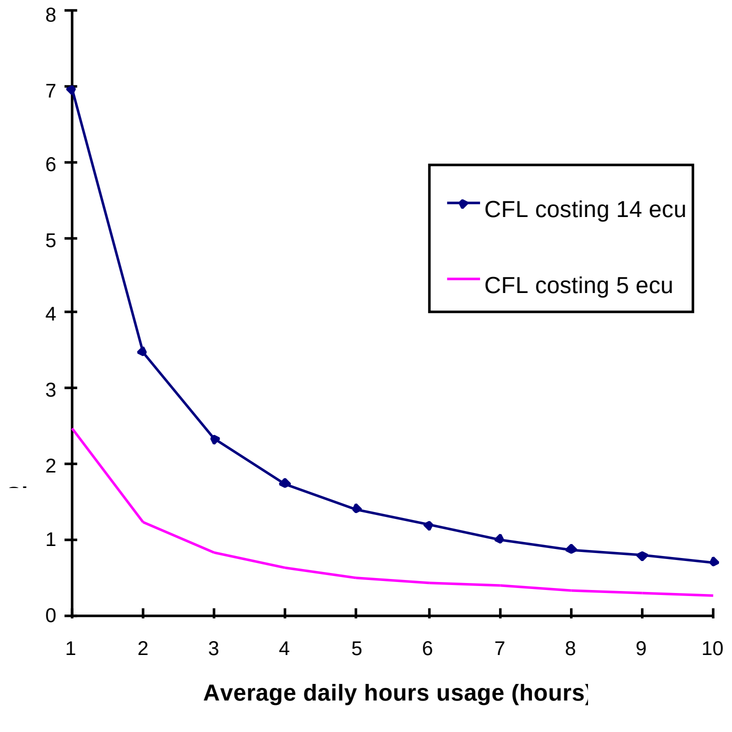

Figure 2-1 Cost-effectiveness of CFLs

2.1.4 CFL myths and concerns

Although the economics of using CFLs can be favourable, there are a number of confusing messages about CFLs in existence which discourage people from using them. A major problem is lack of knowledge among consumers about the characteristics of CFLs and how to use them appropriately, exacerbated by the wide range of CFLs currently available and the rapid advances that have been made in the technology. While some concerns expressed about CFLs are well founded, they do not always take the full picture into account. Other concerns may be due to bad experiences with the early technology or low-quality products and do not apply to the high quality CFLs now available. Mis-conceptions about the performance of CFLs are often the result of mis-application of the technology.

Mercury and disposal
It is true that CFLs contain mercury whereas incandescent bulbs do not - this is an important issue when it comes to disposal of the bulbs. However, pollution resulting from the electricity used by these bulbs is often overlooked - mercury emissions from fossil fuel electricity generation are around three times greater for incandescents than for CFLs. Mercury emissions from power plants cannot be recycled, unlike mercury contained within the CFLs. Also, further reductions in mercury pollution for a given amount of light are possible through the use of more efficient ballasts, which extend the life of the CFL (Mills 1993, Begley and Linderson 1991, Gydesen and Maimann 1991).

CFLs typically contain about 5 mg of mercury, which is actually six to eight times less than conventional fluorescent strips and has decreased from 15mg (DEFU 1996). This is likely to decrease further as the technology continues to improve - there are already CFLs on the market containing only 3 mg per bulb (Lundberg 1997). However, in the meantime, there need to be systems in place, easily accessible to the general public, for the proper disposal of these light sources. Both mercury and phosphors from discarded fluorescent sources can be recycled. Mercury-containing light sources are classified as hazardous waste in Austria, Belgium, Germany, the Netherlands and Switzerland. There are already recycling systems in place across Europe - in 1993, Germany had the largest bulb collection infrastructure in the world (Mills and Borg 1993). Osram has also become involved in developing appropriate recycling equipment (DEFU 1996) and in Sweden, it is possible to deposit used fluorescent lights at IKEA furniture stores for mercury recycling (Lundberg 1997). Integral ballast CFLs are more wasteful than pin based CFLs, since both the bulb and ballast are discarded, and are more costly to recycle because the ballast has to be separated from the bulb.

Hence, the use of CFLs, instead of incandescents, actually decreases levels of mercury pollution and the mercury is in a form that is easier to reclaim. Therefore, with appropriate disposal mechanisms in place, the presence of mercury in CFLs need not discourage their wider use.

Total harmonic distortion and power factors
Utilities are often concerned with the effect of CFLs on the electricity transmission systems through harmonic distortion. The choice of ballast affects the extent to which power quality is disturbed. Most ballasts now have high power factors giving low total harmonic distortion as well as being more efficient. Studies have demonstrated that CFLs actually have very little adverse effect on the power quality of the supply network (Gothelf 1997, Stymne 1997, DEFU 1996, Audin *et al* 1994, Jennings 1993) and may even reduce voltage distortion (Gothelf 1997). The major causes of harmonic distortion in the domestic sector were found to be TVs, videos and computers. There is still a great deal of debate over this issue, but with high power quality products now common, such concerns are of less relevance.

Improvements in technology
Electronic ballast CFLs represent a major improvement on magnetic ballasts, typically being 75% lighter in weight and 50% smaller in volume (DEFU 1996) as well as being more efficient and producing light of a better quality. However, most consumers are unaware of the difference between the two ballast types and incorrectly assume that any difficulties experienced with magnetic ballasts are true for all CFLs. Those people who bought magnetic ballast CFLs when they first appeared on the market may not realise that the technology has now vastly improved. Unfortunately, inferior magnetic ballast CFLs have not yet been eliminated from the market. These are often available at a much lower price than the electronic equivalent and so are likely to be the first type of CFL people try, leaving them with a bad impression of the technology. The image of CFLs is also damaged by cheap, low-quality electronic ballast CFLs which give poor light quality and often fail early. People need advice and guidance as to the best products and applications, which could be provided through labelling or by publishing a list of recommended products, as in Denmark and Sweden. The technology is continually improving and changing, with bulbs that are smaller, lighter and of different shapes. While this provides greater flexibility, it also adds to the confusion and may mean a lack of confidence among consumers in the continuity of the technology.

Some of the problems often associated with CFLs include:

1. *Size and bulk*
   Integral magnetic ballast CFLs are often large, bulky and heavy making it difficult to use them in existing fixtures. Electronic ballast CFLs are typically smaller and lighter in weight and therefore may be suitable for use in a wider range of fixtures. Such problems are not relevant to dedicated systems, since the fixture is designed around the CFL and the bulb is smaller and less heavy because it does not include the ballast.

2. *Flicker, noise and start up delay*
   Flicker (light modulation), hum and a long start up delay are often experienced with magnetic ballasts, but can be avoided by using electronic ballasts. However, even with 'instant start' electronic ballasts, where the bulb comes on immediately, there may still be delay of up to three minutes before full light output is reached which may be inappropriate in some cases. Manufacturers are working to reduce this start-up time further (DEFU 1996).

3. *Switching effect*
   CFLs operating on magnetic ballasts and those using low-quality electronic ballasts are sensitive to frequent switching. However, tests on high quality electronic ballast CFLs indicate that their operating life is unaffected by frequent switching, based on a cycle of three minutes on and five minutes off for up to 20 000 ignitions (Pedersen 1997, Stiftung Warentest 1995).
4. *Radioactivity*
   The starting mechanisms of magnetic ballasts contain small amounts of radioactive isotopes to ensure good starting performance. The resultant alpha and beta radiation is absorbed by the material enclosing the ballast. Gamma radiation is also emitted, but at low levels, thought to be negligible for humans (ELC 1990). Therefore, radiation is not necessarily a problem while the CFL is in use, but proper disposal of these bulbs is important. Electronic ballast CFLs have the advantage that they do not contain any radioactive material since they use a different starting mechanism.
5. *Health*
   Many people are concerned about the health implications of using fluorescent light (Beckstead and Boyce 1992). This may be related to concerns about mercury or radioactivity, but is more often due to flicker from the lights. Studies in Sweden have found that people hypersensitive to electricity are affected by flicker from fluorescent lights on conventional magnetic ballasts. This was not such a problem with high frequency electronic ballasts (Lundberg 1996).
6. *Poor light quality*
   CFLs are often thought to give a poor quality of light, both in terms of the colour and brightness. While this may have been true of earlier technologies, developments in the phosphors used have led to improvements in the colour temperature of CFLs, resulting in a warmer light. However, the light from many low-quality bulbs is still poor, damaging the image of higher quality products. There are also a number of other reasons for light output to be lower than expected. CFL efficacy varies with wattage and the ballast used, affecting light quality. Light output diminishes by up to 30% with age and is sensitive to temperature and operating position. In addition to this, manufacturers often overstate CFL performance. Allowing for such factors, it is better to use a three-to-one wattage equivalence between CFLs and incandescents, rather than the usual recommended four or five-to-one ratio (ie replacing a 60W GLS bulb with a 20W CFL, rather than 11W or 15W). The performance of the CFL is also dependent on the fixture it is used in - this is covered next.

Mis-application of the technology

Even purchasing a high quality product does not guarantee satisfaction, particularly when using integral ballast CFLs in fixtures designed for incandescent bulbs. CFLs are not appropriate for all applications where incandescents are normally used, such as accent lighting where a bright focused beam of light is required. One of the most important factors to consider is the different light distributions of CFL and GLS bulbs. For instance, in fixtures designed for the downward light distribution of GLS bulbs, the shade would block light emitted in the horizontal plane by a CFL. This difference in light distribution also means that CFLs do not work well with reflectors designed for an incandescent bulb. Obtaining optimum performance from a CFL is not simply a case of buying a bulb of the correct wattage and installing it in the fixture, as it is with GLS bulbs. There are additional considerations to take into account, such as bulb orientation and operating temperature. Most householders are unlikely to be aware of all these issues and there is a risk that they will install CFLs in an inappropriate fixture or location leading to dissatisfaction and a negative perception of the bulbs. Therefore, when people claim that CFLs are not bright enough or give a poor light quality, it is more likely to be because of mis-application of the technology rather than a fault of the CFL itself.

2.2 LIGHT FIXTURES

There is a vast array of different light fixtures available, reflecting the number and diversity of fixture manufacturers throughout Europe. With any light source, the fixture is crucially important in determining the distribution and quality of light provided by the luminaire. However, most people buy fixtures on the basis of their appearance and design with little consideration of this interaction with the light source. The broad classifications used in this study are useful when considering the suitability of fixtures for use with CFLs and how to influence this market.

There are three main classes of fixture: ceiling mounted, wall mounted and free standing. Ceiling fixtures can be further subdivided into pendant, surface and recessed. Free standing fixtures can either be floor standing or table/desk lamps.

Fixtures can also be classified by the way in which they are installed in the house (ie whether they are fixed or portable). Fixed light fixtures are typically located on the ceiling or wall and operated by a wall mounted switch. These fixtures may be wired into a separate electrical circuit solely for lighting. Portable fixtures are those with a switch either on the fixture itself or on the cable and which plug into a wall socket, connected to the general electrical circuit. While free standing fixtures are always classified as portable, wall and ceiling fixtures may be classed as fixed or portable in different countries, depending on how the lighting is installed. Specification of light fixtures during the building of a house and hence the extent to which the fixed light fixtures are actually considered to be part of the house and are left behind when people move, also varies between countries.

The majority of fixtures currently available on the market and installed in people’s homes are designed for GLS bulbs, with a bayonet or screw socket. Pin based halogens and fluorescent light sources require different fixtures with the appropriate socket and transformer or ballast.

Dedicated systems for CFLs, where the ballast is incorporated into the fixture, are already widely used in the commercial sector but are not yet common in households. These systems have a number of advantages over the use integral ballast CFLs in existing GLS fixtures - they solve some of the technical problems associated with the use of integral units, making energy savings simpler as well as providing better light quality:

- GLS and CFLs have different light distributions. Fixtures specifically designed for CFLs will be appropriate to the light distribution from a CFL.
- Incorporating the ballast into the fixture means that the size of the CFL is reduced, allowing more flexibility in fixture design.
- CFL dedicated fixtures ensure optimal performance of the light source since they are based on the characteristics of the CFL.
- A ballast usually lasts for 40 000 to 60 000 hours and so can power around five to six CFLs over its lifetime. Therefore, incorporating the ballast into the fixture minimises waste and reduces the cost of replacement bulbs. This makes the economics of CFL replacement more favourable.
- Pin based CFLs are cheaper and easier to recycle than integral ballast CFLs.
- The savings from using CFLs in dedicated fixtures are guaranteed since there is no possibility of returning to the use of GLS bulbs in these fixtures.
- The use of pin based CFLs for dedicated systems, rather than requiring different bayonet and screw based bulbs, could facilitate harmonisation of the residential bulb market across Europe.

There are also some disadvantages with current dedicated systems which need to be tackled before their use can become more widespread:

- Not all CFLs and ballasts are compatible - bulbs above 9W often require different bases and ballasts for each wattage and are therefore not interchangeable. This is a major barrier to the wider use of dedicated systems.
- Since the ballast lasts for around six CFLs there needs to be a guarantee that replacement bulbs will be available in the future, within the lifetime of the fixture. A ballast in a fixture used for three hours a day could still be functioning after 50 years, although the fixture will probably have been replaced by then.

2.3 CONCLUSIONS

Since the widespread introduction of electric lighting into homes at the beginning of this century, incandescent light sources have been the dominant technology. Some of the initial barriers to the installation of incandescent lighting are similar to those currently being experienced in the CFL market. For instance, CFLs are a relatively new technology, not yet widely used, even though the first CFLs appeared on the market almost twenty years ago. Whilst CFLs can be used in the existing light fixtures, they perform better when used in specifically designed fixtures, as was the case with using incandescents in fixtures designed for gas lamps. It took over forty years for incandescent fixtures to become common - this process needs to be quicker for CFLs.

CFLs are a different and unfamiliar technology compared to traditional incandescents. There is a great deal of confusion about them among consumers, preventing their wider use. This is partly a result of bad experiences with the early magnetic ballast CFLs, some of which are still available on the market, perpetuating negative opinions about CFLs. Low-quality bulbs are also detrimental to the image of CFLs. The interaction between the light source and the fixture is crucial in generating the required distribution and quality of light. Misconceptions about the performance of CFLs are exacerbated by the fact that the majority of fixtures on the residential market are designed for incandescent bulbs and are therefore not always suitable for use with CFLs. The use of dedicated fixtures tackles many of these issues, as well as improving cost-effectiveness and reducing wastage. However, there needs to be greater continuity and compatibility of the bulbs and ballasts used in these fixtures, with a greater range of fixture designs, if they are to be successful.

CHAPTER 3: RESIDENTIAL LIGHTING MARKET

An appreciation of the structure and players involved in the lighting industry is necessary to understand how this market can be influenced. There is an interplay between what is available on the market and the perception of lighting in any one country.

The residential lighting market is more complex than markets for other domestic appliances since it consists of two inter-dependent sectors: light bulbs and light fixtures. These two markets have quite different structures, the light bulb market being similar across Europe in terms of manufacturers, products and retail outlets, whereas the light fixture market is more diverse and country specific.

Sales data for both these markets are sparse and, where data are available, the distinction between the residential and commercial sectors is often unclear. Actual data on residential light bulb sales are only collected in a limited number of European countries at present, with differences in level of detail, coverage of the market and the different bulb types. With the current moves to establish European wide data collection, these differences need to be resolved and coverage increased. Data on fixture sales are also limited and typically only given in terms of value which is of limited use compared to volume sales data.

The following section gives a broad overview of the residential lighting market in Europe (in some cases limited to countries within the EU), covering manufacturers and retailers, and discusses the aspects of the market that influence the successful introduction of CFLs.

3.1 MANUFACTURERS

3.1.1 Light bulbs

Across Europe, the majority of light bulbs for both residential and commercial use are produced by three major light source manufacturers: Philips, Osram (Siemens) and GE Lighting (Tungsram, Mazda). Their headquarters are located in the Netherlands (Philips), Germany (Osram) and the USA (GE Lighting), although production is world-wide. These companies each account for around 30% of residential light bulb sales in Europe. There may be slight variations in the wattage or type of bulb sold in each country, for example, pin-based CFLs of a higher colour temperature are sold in Spain because these give a brighter light (Beronius pers comm 1998) and GE Lighting produces CFLs in six different colours for different countries (DEFU 1996). But, on the whole, products do not differ significantly between countries. The UK and Ireland represent an exception because of the requirement for bayonet based bulbs in the residential sector. French households also use bayonet based bulbs to a certain extent, although screw-based bulbs are more common. A further difference in the UK is that the public electricity supply operates at around 240V, rather than 230V supply in the rest of Europe. Hence specific incandescent bulbs must be produced for the UK, because their life time and light output is sensitive to voltage. The Europe-wide harmonisation of electricity supply to 230V (+/- 10%) by the year 2003 means that manufacturers have to adapt their products accordingly. This is of particular relevance for incandescent light sources, unlike electronic ballast CFLs.

3.1.2 Light fixtures

The crucial difference between the bulb and fixture manufacturing industries is that there are hundreds of relatively small fixture manufacturers, generally specific to each country, rather than a few multi-national organisations. This is an important factor to consider when it comes to influencing the market, as is the extent to which fixtures are imported into Europe and their country of origin. The disparate nature of this industry makes the collection of information difficult. Actual data on the light fixture market were obtained for only eight of the EU countries (Austria, Belgium, France, Germany, Italy, Netherlands, Spain, UK) and only in terms of value, not volume. As with the bulb market, there are also difficulties in apportioning production and sales between the residential and non-residential sectors. Despite these limitations, it is still possible to give a general overview of the European market.

Unlike the light source industry, companies involved in the fixture industry do not tend to operate in both the residential and commercial sectors. In 1995, the top three producers of residential fixtures were Massive (Belgium), Emess (UK) and Hustadt (Germany). The top 50 companies in this sector represent only 27% of production, illustrating the small scale of companies. By comparison, in the non-residential lighting market, over 80% of production is concentrated in the top 50 companies. Philips is particularly prominent in the non-residential sector, responsible for 12% of total production in all sectors in the countries covered (CSIL 1996).

The residential fixture market in the eight countries covered is worth in the region of 5 billion ecu in 1995 (derived from CSIL 1996), representing around 55% of the fixture market for all sectors. Table 3-1 summarises the market in terms of sales, production and numbers of companies in each country. Germany is the leading producer, although with relatively few companies. Belgium, Italy and Spain are the only net exporters of residential light fixtures. Italy is the major exporter, exporting mainly to Germany and France, and also has the largest number of manufacturing companies.

Table 3-1 European residential fixture market

	Sales 1995 (million ecu)	Production 1995 (million ecu)	Number of companies
Austria	185	156	n.a.
Belgium	126	145	n.a.
France	497	409	130
Germany	1687	1512	150
Italy	639	1338	350
The Netherlands	272	102	n.a.
Spain	391	475	220
Scandinavia (S, DK, N)	318	289	n.a.
UK	630	485	320
Total	4745	4911	1170

Source: CSIL 1996
Note: n.a. - not available

A high proportion of trade is within Europe, the majority of fixtures sold being manufactured in Europe. Levels of production and export from the Eastern European countries are increasing due to direct investment by Western European companies. As with the bulb market, there is also increasing competition from Far Eastern imports. Table 3-2 shows the international trade figures for seven of the EU countries (Belgium, France, Germany, Italy, Netherlands, Spain, UK), indicating the balance of trade between the various regions. These figures cover both the residential and commercial sectors - it is not possible to identify the relative proportions for each.

Table 3-2 International trade in light fixtures (all sectors)

	Exports (million ecu)	Imports (million ecu)	Balance (million ecu)
Europe	2121.3	1649.0	472.3
Asia	348.3	452.4	-104.1
America	165.3	53.2	112.1
Africa	72.5	10.7	61.8
Other	43.9	3.5	40.4
Total	2751.3	2168.8	582.5

Base: Belgium, France, Germany, Italy, Netherlands, Spain, UK
Source: CSIL 1996

Data broken down by fixture type (ceiling, wall and free-standing) are more difficult to interpret because of variation in prices within and between the different classes. In the residential sector, ceiling fixtures represent the majority of production, in terms of value, for all countries. This category tends to be at the higher end of the price range and so this does not necessarily reflect a correspondingly high volume of sales.

Data obtained on fixtures were also classified by style in broad categories of ‘traditional’, ‘modern’ and ‘design’. This is not particularly informative, with most countries producing a mix of traditional and modern designs. Exceptions are the Netherlands and Scandinavia, with a high percentage of production being modern designs.

In addition to variation in aesthetic requirements, the requirement for bayonet sockets in the UK and Ireland limit the extent to which the European fixture market can be harmonised.

3.2 RETAILERS

Despite differences in the manufacturing industries, the retail structure for lighting appears to be similar in most European countries, with limited overlap between bulbs and fixtures. There are five main types of retail outlet:

1. Supermarkets
2. DIY (Do-it-yourself) stores
3. Department stores
4. Furniture stores
5. Lighting specialist stores

Light bulbs are sold in all five outlets although the range available varies. Supermarkets tend to stock mainly incandescent bulbs, but CFLs are becoming more common. Lighting specialists usually have the most extensive range of bulb types, particularly of CFLs and halogens. Department stores, furniture stores and DIY outlets lie somewhere in between these two extremes. In recent years, some DIY stores have been selling cheap CFLs (3-5 ecus each) to attract more customers. However, throughout Europe, most people buy their replacement bulbs in supermarkets as part of their regular shopping trips.

Supermarkets do not sell light fixtures, therefore people have to buy their fixtures in a different place to where they normally buy bulbs, although the type of bulb they buy is actually dictated by the fixtures they own. Fixtures are sold in the other four outlets, with a trend towards increasing sales through DIY stores at the expense of sales in furniture and department stores. Residential light fixtures are not only purchased by householders - builders and architects are both involved in the specification and purchase of light fixtures for the home but may use different distribution channels, such as a wholesalers.

No breakdown of sales value was available by the different outlets for the residential market alone. For the total fixture market, lighting specialists sell 19% of all fixtures compared to 7% in both DIY and department stores and 5% in furniture stores (CSIL 1996). The remaining percentage is non-residential sales. Since these percentages are based on sales value and lighting specialists are likely to sell more expensive fixtures, volume sales may be more evenly distributed through the outlets.

Sales volume data provide information on the rate of turnover of bulbs and fixtures in the stock. Such figures are necessary to appreciate the time-scale for the introduction of a new technology, such as CFL dedicated fixtures, through natural turnover in the stock. The turnover of bulbs in the average house, derived from sales and ownership data, forms the basis of the stock models which estimate residential lighting electricity consumption and are discussed in Chapter 8. Turnover is more difficult to derive for fixtures since data are in value rather than volume of sales. The figures in Table 3-1 indicate that, across the 140 million households in the eight countries, the average household spends around 33 ecu per year on fixtures. This is assumed to be equivalent to the purchase of one fixture each year per household across the EU, either new or replacement. These figures are supported by a recent survey in the UK which found that two-thirds of respondents had purchased a fixture in the previous six months, the majority of people spending up to 38 ecu on their purchase. People were most likely to spend over this amount for floor and ceiling fixtures (Pearce pers comm 1997).

3.3 The market for CFLs

CFLs first appeared on the European market in the early 1980s although the year of introduction in individual countries varies, the most recent being in Eastern Europe. From the outset, CFLs have been looked upon as a direct replacement for incandescent bulbs, focusing on the use of integral ballast CFLs in the existing fixtures. People need guidance on the appropriate application of these bulbs but this is not easy given the current structure of the lighting market. People are not used to having to seek advice about how to use their light bulbs. Also, since many people buy their bulbs in supermarkets, informed retail staff are not available to give such advice and they cannot observe the interaction between the bulb and fixture to help choose the most suitable bulb. Even most lighting retailers do not usually display CFLs in luminaires in their showrooms.

In 1997, global sales of CFLs to all sectors were around 356 million, with 120 million sold in Europe, being split almost equally between pin-based and integral ballast bulbs (Borg 1997). Electronic integral ballast CFLs are replacing the earlier magnetic ballast technology. The proposed EU directive, improving the efficiency of ballasts on the market, will help formalise this trend. In Western Europe, the CFL market has been increasing steadily at around 10-15% per annum over the past four years, with a slight decrease in GLS sales during this time period. In order to meet the increasing demand, manufacturers are investing in new production plants, mainly in Eastern Europe (for example, Tungsram in Hungary) and developing countries, where labour costs are lower. China has now taken over from the USA as the world’s single largest CFL producer (Nelson 1996). In the past, CFLs imported from the Far East have typically been cheaper but of poor quality. However, the quality of these bulbs appears to be improving. In 1997, both Philips and GE lighting purchased CFLs from independent Chinese manufacturers to sell under their own labels (Borg 1998).

There is a lack of fixtures suitable for CFLs on the residential market, both those for use with integral ballast CFLs and fixtures dedicated to CFLs, although there is a wide range of dedicated fixtures in the non-residential sector. Manufacturers claim that it is lack of interest from the retail sector that is the major barrier. This appears to be borne out by a survey of manufacturers and retailers in Sweden (Brunnström 1997). Although all retailers surveyed stocked at least one CFL fixture, the range was very limited. In terms of manufacture, dedicated fixtures represented 31% of ceiling and 25% of wall fixture production. While these proportions are still relatively low, it does indicate that there is a greater range of CFL fixtures manufactured than currently found in retail outlets.

Production of CFL fixtures requires close liaison between the bulb and fixture manufacturers to ensure compatibility and continuity of technologies used in the fixtures, such as the bulbs and ballasts. In the past, there has been no particular need for these two industries to collaborate, since the technology has not changed drastically. However, the introduction of halogen lighting required the design and manufacture of special fixtures, with sockets for pin based bulbs. There is now a vast array of dedicated halogen fixtures on the market, demonstrating that collaboration between the two industries is possible and can be highly successful. This may have been partly because designers and manufacturers look upon halogens as an exciting light source and enjoy working with it.

The involvement of designers is crucial - people tend to buy fixtures because they like the design and so there needs to be attractive and original CFL fixtures available. However, in 1995, only 1.9% of turnover was invested in product design across both residential and non-residential fixture manufacturers (CSIL 1996). Current CFL fixture designs are often based around traditional GLS fixtures, which are not necessarily appropriate. Student competitions in both Sweden and the UK have produced innovative designs which optimise the shape and properties of a CFL, rather than treating it as a replacement incandescent bulb. EM (the Swedish National Energy Administration) are aiming to encourage liaison between designers and fixture manufacturers in the production of CFL fixtures through a programme subsidising the designers costs. NOVEM, the Dutch Energy Agency, is considering setting up a similar scheme.

3.4 CONCLUSIONS

The two lighting industries, light sources and light fixtures, are quite distinct in terms of manufacturers and there is currently little collaboration between the two. The size and type of companies involved are very different, the three major bulb manufacturers being universal across Europe and between sectors, whereas the fixture manufacturers are smaller, more country specific and focused on the residential sector. Despite some similarities in the retail structure, there is a disparity between bulbs and fixtures since most people buy their replacement bulbs in supermarkets, where fixtures are not available. This does not give people the opportunity to look at how the bulb and fixture interact. While this is not an issue when purchasing incandescent bulbs, it becomes more important with CFLs. Households within the EU are thought to purchase an additional or replacement fixture each year, representing an opportunity to introduce dedicated fixtures into peoples' homes. The current retail structure, lack of informed retail staff, lack of collaboration between the manufacturing industries and lack of dedicated CFL fixtures are all obstacles to the success of CFLs.

CHAPTER 4: EUROPEAN OWNERSHIP AND CONSUMPTION

Residential lighting is not an area which has been studied in detail within the majority of European countries, let alone across Europe. Information in this sector is sparse and difficult to obtain, with knowledge dispersed between utilities, government departments, research agencies, consultants, manufacturers, retailers and consumers. Market data specific to the residential sector are poor. Other data, such as household lighting electricity use and the number of bulbs per household, are often rough estimates with little research done to confirm these figures. In studies which have monitored other domestic electricity end uses, lighting is often relegated to a miscellaneous category due to difficulties in identifying how much electricity goes into the lights.

This lack of knowledge and research has two consequences: it is possible that estimates of residential lighting electricity consumption are inaccurate and domestic lighting is therefore not considered to be an important area from a policy perspective. Secondly, without a reliable base line, it is not easy to identify or evaluate any savings that can or have been made.

As part of this project, data relevant to lighting were collected for all fifteen EU countries as well as six associate members and assembled into ‘country pictures’, building up a comprehensive picture of residential lighting in homes across Europe. These profiles represent the best currently available information obtained from the various sources in each country and serve several purposes. They:

- provide a useful source of information for each individual country,
- allow comparisons between countries,
- identify gaps in the information and therefore indicate areas for future research,
- highlight inconsistencies in the numbers and where more reliable figures are needed,
- provide the context for the detailed studies of Germany, Sweden and the UK, undertaken as part of the DELight project,
- enable some key indicators for domestic lighting to be identified
- establish the context for residential lighting policy, both at a national and EU level

The country profiles cover basic data, such as ownership and lighting electricity consumption, as well as people’s attitudes to lighting, with a particular focus on CFLs. The key figures are shown in Table 4-1 while the individual profiles are included in Chapter 2 of the Supporting Material, with a full list of references used. Care should be taken when making comparisons between countries because of the low confidence in some of the figures. The following summary highlights the important findings.

4.1 ELECTRICITY CONSUMPTION

On the basis of the data collected, total residential lighting electricity consumption in the 15 EU countries is about 86 TWh, representing 17% of EU domestic electricity consumption. This lies between cold (refrigerators, fridge-freezers and freezers) and wet (washing machines, tumble dryers and dishwashers) appliances which account for around 23% and 12% of EU domestic electricity consumption respectively. Average household lighting electricity use ranges from 240 kWh pa to 920 kWh pa across Europe, as illustrated in Figure 4-1. Although average hours of daylight are the same for all countries across the year, hours of artificial lighting are expected to differ, with a general downward trend from North to South, which should be reflected in electricity consumption. Assuming this to be true, figures for lighting electricity use appear to be too low for Belgium, Lithuania and the Czech Republic and too high for Spain and Portugal. The majority of figures given are rough estimates, with only three validated by actual measurements of lighting electricity use in households (Bulgaria, France, UK). This indicates the need to revise some of these estimates.