

DISCUSSION PAPER
(Revised version)

Swedish Energy Agency (STEM)

Market Transformation Strategy Compact Fluorescents in Residential Lighting

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1. Summary

This document discusses the options to improve the quality and the acceptance of compact fluorescent lamps (CFL) for general illumination by Swedish households.

The potential savings from lighting in households exceeds appliances by a wide margin. While savings on the order of 10% can be achieved with major appliances such as refrigerators, lighting technologies can save 50 % or more in typical installations. Furthermore, lighting upgrades involve relatively lower costs which allows the benefits to be spread more widely than is possible with any other energy efficiency measure

CFLs typically use 5 - 8 times less energy to provide a given light emission during the operational phase than incandescent lamps. Energy consumption during the production and disposal phases is also lower. Incandescent bulbs have distinct disadvantages: high operating temperatures, short bulb life, and the inconvenience of more frequent bulb changes. Incandescent bulbs also create “hot spots” of light within fixtures and scalloping (alternating patterns of light and dark) on adjacent walls, while CFLs can provide a more diffuse, continuous light. However, CFLs due to a wide-beam spread are not appropriate in applications which require concentrated light beam.

A market transformation program is suggested to bring about lasting changes toward higher energy efficiency in the target market for CFLs. In contrast to traditional energy efficiency programs, market transformation programs typically take a more comprehensive and long-term view of the target market, addressing both the demand and supply sides of the market as well as the sustainability of the changes in the market after the end of the program.

STEMs CFL lighting program may consist of several discrete tasks, initial performance specification development, retailer partner recruiting, CFL testing, and spreading of qualified/disqualified CFL product lists to general public, followed by aggressive information and promotion efforts by the stakeholders (e.g. Swedish Energy Agency, Regional Energy Centres, energy advisers, retailers, and manufacturers etc.).

The program is seen as a catalyst to enhance market forces. There is a strong emphasis on partnership between government and the private sector in order to achieve common goals. Given the small size of the Swedish market, it is recommended to team up with one or more (neighbouring) countries to address the CFL issues e.g. through common CFL performance specifications and mutual recognition of tested/approved CFLs.

The Program draws heavily from the experiences of US DOE Energy Star program. Compact fluorescent lamps were first covered by an Energy Star performance specification in 1999. The original specification addressed luminous efficacy, lumen maintenance at 40% of rated life, and average rated life. Subsequent versions of the specification addressed lumen maintenance at 1000 hours, rapid cycle stress testing, and interim lifetime testing. A new version of the specification may include more stringent criteria regarding efficacy, run-up time, and sample-to-sample performance consistency.

2. The intent

The intent of this program is to move consumers away from incandescent lamps to energy-efficient compact fluorescent lighting for residential applications and, thereby, increase overall CFL market share. The program aims to “provide specific parameters and direction” to encourage the sale and marketing of “high quality, high efficiency CFLs.”

The program includes minimum product performance specifications and outlines what CFL manufacturers need to do to qualify to enter the Swedish market.

The program strives to:

- Minimise the chances of under performing CFLs entering the Swedish market.
- Limit the number of discrete CFL bulbs types being stored and marketed in Sweden.
- Lower the CFL testing costs for suppliers and for STEM.
- Reduce the program administration costs for STEM.
- Reduce the compliance costs for all concerned parties including STEM.
- Provide a reasonable basis upon which STEM can decide to qualify or disqualify a CFL for the Swedish market.

3. Definitions

Self-ballasted compact fluorescent lamp – A compact fluorescent lamp unit that incorporates, permanently enclosed, all elements that are necessary for the starting and stable operation of the lamp, and which does not include any replaceable or interchangeable parts. CFLs with replaceable glass parts, globes and other covered lamps, lamps with double, triple, quad, spiral and circling configurations as well as lamps with inbuilt reflectors.

4. Background

In 1980, for the first time, CFLs were introduced in the Swedish marketplace. However, it has taken more than 25 years for them to gain widespread recognition in the Swedish residential lighting market. While CFLs have about 3 % of the national market in terms of unit sales for light sources, they have achieved higher market penetration in some market segments, primarily hotel and commercial sectors.

Swedish authorities have in the past run various campaigns to promote greater use of CFL s in Sweden as a replacement for incandescent lamps.

The first campaign was launched by NUTEK in cooperation with IKEA in 1993, when IKEA celebrated its 50th anniversary. IKEA through federal government subsidy donated a CFL to each of its “IKEA Family” members. NUTEK prepared a small information leaflet containing information about energy efficiency (lumen/watt) and lamp life (hours) of CFLs, for distribution with each lamp. However, this information leaflet had no relevance for the actual lamps distributed by IKEA i.e. there was no established or known relationship between how the quality of lamps distributed by IKEA to the households corresponded with the performance figures mentioned in the leaflet. In retrospect it may be said that the CFLs distributed by IKEA were of extremely poor quality.

There were, however, some advantages gained through this campaign i.e. that IKEA got seriously involved in the market for CFLs, not only in Sweden but globally. The quality of IKEA marketed CFLs has since 1993 improved drastically, while the prices have fallen substantially, in turn, leading to a greater market penetration of CFLs around the world.

During 1999, the Swedish Energy Agency (STEM) published a brochure titled “four questions on compact fluorescent lamps”. The brochure covered the following four questions 1) surplus heat from lamps 2) harmonic distortions 3) mercury 4) and electromagnetic radiation. The arguments presented in the brochure are in general still valid today. However, while the brochure answers some of the consumer concerns, it is limited in its range of addressing all the major consumer concerns.

During 1999, the Swedish Consumer Agency commissioned a study (1999:6) titled “How the light is perceived – The difference between incandescent and compact fluorescent lamps.” Two studies, one amongst fixture manufacturers and one amongst the retailers was conducted during 1996 to determine the market availability of CFL based fixtures for use in homes. The study founded that the market for CFL based fixtures was dominated by ceiling fixtures with 144 models from 21 vendors followed by wall mounted fixtures with 118 models from 19 vendors. On the other hand, there were limited fixtures available as table lamps (51 models from 13 vendors) and as floor torchieres (37 models from 14 vendors). The study did not address the issue of fixture quality, just the number of available CFL fixtures.

The study also interviewed twenty persons about light intensity, colour rendition, contrast and flicker comparison on a visual analogue scale (VAS) between a CFL fixture and an incandescent lamp fixture. The study concluded that there was no difference perceived between CFL and incandescent lamps by the study persons. The study, thereby, proved that a well designed fixture with a well chosen CFL with colour temperature close to an incandescent lamp (warm white) will be perceived similar to an incandescent lamp by a viewer. However, the process of finding the right lamp by a consumer requires testing between many different lamps to find the right light colour, which is not practically feasible for a consumer to realize. Even the current CFL products show a wide variation in correlated colour temperature (CCT) and chromaticity coordinates, both between manufacturers and within a manufacturer’s own CFL product lines. This means that from lamp to lamp, a multitude of colour differences can be observed, even among lamps labelled with the same CCT.

During 2004, the Test Laboratory then a part of the Swedish Consumer Agency (now a part of Swedish Energy Agency) carried out its second ad hoc testing of 20 different CFLs from Osram, GE, Philips, IKEA and Sylvania. The testing authority concluded that there was no correlation between price and performance of the CFLs. The information on packaging was often deficient in terms of light quantity. Many models had light output claims that could only be achieved at the optimum operating temperature and/or in some optimum burning position that achieved an optimum internal temperature. Many light output claims were outright exaggeration, often by about 15 percent and in a few extreme cases by 25 percent. Furthermore, it was common that the indicated life was inaccurate.

It may be added that the CFL testing at the Test Laboratory was not carried out against any national or international standard or performance specification but rather against the declared information by the lamp vendors. The value of such ad hoc and irregular testing has limited market transformation value because of the rapid changes in product design, whereby initial data is no longer representative of existing products.

During 2004, Nordic Eco labelling for CFLs was publicised. To qualify for an eco-label light sources must fulfil requirements as to:

- Energy consumption
- Mercury content
- Colour rendering
- Lifetime

5. CFL experiences during the 90s

In general, it may be concluded that throughout the 90s compact fluorescent lamps being marketed usually did not produce full light output until they warmed up for a minute or two, some producing as little as 20-25 percent of their full light output when first started. The light produced by CFLs was usually slightly different from that of incandescent lamps, often slightly less yellow and pinker, purple, or bluer. The spectral output of these lamps was usually concentrated in a few specific bands of the spectrum, and this could slightly distort colour rendering. The colour difference resulted in less than pleasing contrast with ordinary lamps and ceiling fixtures.

Some types (usually iron ballasts) produced an annoying 120 Hz (or 100 Hz) flicker as well as audible buzz. They could also produce Radio Frequency Interference (RFI).

In 1990s CFLs were still so big and bulky that consumers had to replace lamp shades, change lamp harps, or get modification kits to make the lamps fit in some of their fixtures.

The consumers were not informed by the retail trade, CFL manufacturers or Swedish Energy Agency that, compact fluorescent lamps should only be used where they are left on (on an average) at least 15 minutes, preferably half hour, once they are turned on. Since, starting a fluorescent lamp causes wear and tear on the electrodes.

The consumers were not informed either that CFLs operating at cold temperatures may cause reduced light output or erratic operation or that compact fluorescents also did not withstand excessive heat i.e. in enclosed or recessed ceiling fixtures.

Early bulb burnouts and poor luminance maintenance were a major source of dissatisfaction for consumers, especially since long life was one of the advertised strengths of CFLs. This would be problematic for any technology, but especially so for one that demanded such a price premium compared to the conventional product it replaced.

The up-front cost was substantial: SEK 80 (\$10) to SEK 160 (\$20) for a compact fluorescent to replace a 60 W incandescent bulb. Even if the CFLs lasted as long as 5 to 10 incandescent bulbs, they cost more than buying that many incandescent bulbs and required the purchase to be made all at once, rather than over time.

6. Present Market Barriers

6.1 Consumer Awareness of CFLs

Consumer recognition and awareness of CFLs is high in Sweden and the consumers know about some of the benefits associated with CFLs. What is then holding the Swedish market back? CFLs have an image problem that may be hard to overcome. For many consumers compact fluorescent invokes connotations such as harsh, cold, glaring, flickering, buzzing, artificial, and ugly lighting associated with eye strain, noise, greenish skin tones, and institutional settings. Even though, in recent years major improvements have been made in CFL size, shape, light output, efficacy, colour, and electrical characteristics, first consumer impressions may be long lasting.

6.2 Consumer Purchasing Behaviour

Swedes typically purchase light bulbs at grocery stores; however, it is not likely that CFLs can be found there in any significant numbers or at competitive prices. This lack of availability of CFLs at the location where consumers are making light bulb purchases doubtlessly hurts sales. Strong promotion of CFLs through mass merchandise at IKEA and Willys stores, for example, has changed some consumer light bulb buying habits. But old habits die hard, especially when buying an incandescent is as convenient as buying a litre of milk.

6.3 Market Entrance Barrier

The way incandescent light bulbs are being marketed in Sweden constitutes a retail or market structure barrier. Grocery stores typically carry only one brand of incandescent lamps, so when customers go to the store they usually only have one brand to choose from.

This also means that even if an incandescent lamp vendor or retailer replaced some of his incandescent lamps with CFLs in a store, for a consumer, comparison shopping across CFL models and technologies will still have to be done store-to-store, rather than within a single store.

The competition for market share among the major lamp companies seems to be based more on competition for the loyalty of retail distribution outlets rather than reaching out to the consumer about the merits of a particular product.

The grocery trade in Sweden is dominated by three major players ICA, Coop and Axfood, which together account for over 70% of the grocery retail trade.

6.4 Lack of CFL Product Information to the Consumers

Retailers competitively allocate selling space to various light source manufacturers and expect them to do much of the work of earning them a reasonable rate of return on that space. Retail outlets typically provide space for the lighting products that they carry, but little else in the way of support to the customer. Thus retailers rely on manufacturer or his representatives to educate consumers about the benefits of their lighting products, set up point of purchase displays, and even maintain inventory on the shelves.

The information on CFLs on the market is confusing and consumers do not know how to choose the appropriate one for their fixtures. The retailers' lack of understanding of the technology is a major market barrier for residential consumers.

6.5 Higher CFL prices

Despite falling prices CFLs are considerably more expensive than the incandescent alternative that they replace. Even if most of the traditional objections in terms of shape, performance and light balance are overcome the higher price remains an obstacle for CFLs to capture a larger market share.

7. STEM's starting position

STEM does not necessarily enjoy a commanding or trusted position vis-à-vis the consumers due to previous campaigns launched by STEM during the 90s. These campaigns may be summed as:

STEM engaged in ill conceived, inconsistent and ad-hoc promotions.
STEM did not take into account the consumer perspective but rather concentrated exclusively on energy efficiency and technical issues.
STEM relied indiscriminately on the information provided by the vendors.
STEM was very passive about dealing with CFL technology failures that affected main benefit claims.
STEM did not study, did not know or admit technology limitations.
STEM did not demand or work to establish minimum performance requirements.
STEM never questioned why long life claims were not backed by a guarantee.

However, positive shift in attitudes amongst consumers about resource consumption and, to some extent, higher electricity prices do present a new window of opportunity for STEM to act. However, increasing CFL market share would take continued marketing and refinement of the message to reach those consumers still not yet convinced. Getting the word out about the new CFLs, showing consumers their value, educating retailers on how to market them– all of these are critical pieces of the consumer acceptance pie.

8. Market Transformation Issues

8.1.1 How to ensure consistent quality of CFLs in the marketplace?

8.1.1.1 The Problem

The issue is how to eliminate low quality CFLs from the market? How to ensure that the retail trade only markets high quality CFLs, thus creating consumer confidence in CFLs?

China is the world leader in CFL production, with roughly 75 percent of the global production taking place within its borders. Total annual output was estimated to be running at close to one billion pieces in 2004 and the number is expected to continue to increase in the future (Global Sources, 2004). There are an estimated 1000 manufacturers of CFLs in China with multiple suppliers of lighting components, electronics, glass, etc. CFLs of varying qualities are being manufactured in China. A number of CFLs of questionable performance have, therefore, the potential to enter the Swedish marketplace. Swedish consumers have no way of knowing how to distinguish between superior performing CFLs and poor performing ones.

Industry collaboration with the manufacturers perhaps would be helpful to ensure CFL quality, though difficult to achieve, given the very large number of manufacturers and most of them being located in China.

It may be added that there are no local manufacturers of CFLs in Sweden.

8.1.1.2 The Solution

8.1.1.2.1 Define What Constitutes a Good CFL?

Define performance criteria that guarantee CFL quality (safety & performance) to the consumer. The following factors may form the basis for a CFL approval.

- o Efficacy (which includes 100-hour lumen output)
- o Rapid Cycle Stress Test
- o 1,000-hour lumen maintenance
- o Colour Rendering (CRI)
- o Correlated Colour Temperature (CCT)
- o Power Factor

- o Run-up Time
- o Starting-up Time
- o Transient Protection
- o Operating Frequency
- o Electromagnetic Interference (EU EMC directive)
- o Lumen Maintenance at 40% of rated life
- o Interim Life Time Test at 40% of rated life
- o Electronic ballasts
- o EU low voltage directive compliance

It also needs to be taken into consideration that in the European Union 11 countries now operate with a supplier voltage of 230V ±10% and that by 2008 all of the EU will be operating with this supply voltage. Many CFLs now last for over 10 years and also many ballasts last for over 20 years so it is very important that all lamps and ballasts are designed to operate safely and efficiently at 250V plus.

STEM's goal is to work cooperatively with retailers to drive the market to offer the highest quality CFLs. A performance specification will give retailers a benchmark of lighting performance and quality around which to rally their purchasing and marketing efforts. The performance specification will, therefore, determine "how does a potential CFL supplier qualify to enter the market"?

The performance specification should be evaluated and revised every few years to ensure compliance with technical developments and to cater for newer consumer concerns, if any.

International CFL Performance Specifications in Existence

There is a myriad of CFL performance specifications (more than 33) in use around the world. A short presentation of the most relevant performance specifications for STEM is provided in the following table.

		ENERGY STAR USA	EU QUALITY CHARTER	EST UK	DANISH ENERGY SAVING TRUST
Starting Time (Secs)		1.0			
Run-up time (mins) 60% stabilised light output		1.0	1.0	1.0	1.0
Efficacy (no cover) < 4500 K	= 5 to < 9W	50	35 @5W. 45 @ 9W	= EU (for class S)	35 @5W. 45 @ 9W
	= 9 to < 15W	55	45@ 9W. 53 @15W	= EU (for class S)	45@ 9W. 53 @15W
	= 15 to < 25W	60	53@15W.61@25W	= EU (for class S)	53@15W.61@25W
	= 25 to < 60W	65	61@25W.72@60W	= EU (for class S)	61@25W.72@60W
Efficacy (no cover) > 4500K	= 5 to < 9W	50	35 @5W. 45 @ 9W	= EU (for class S)	35 @5W. 45 @ 9W
	= 9 to < 15W	55	45@ 9W. 53 @15W	= EU (for class S)	45@ 9W. 53 @15W
	= 15 to < 25W	60	53@15W.61@25W	= EU (for class S)	53@15W.61@25W
	= 25 to < 60W	65	61@25W.72@60W	= EU (for class S)	61@25W.72@60W

Lumen Maintenance (after 2000 hrs) CFLs no cover		0.8	0.88		0.88
Lumen Maintenance (after 2000 hrs) CFLs covered					0.83
Lifetime (hrs)		6000	6000		6000
Power Factor		0.5	0.55		
Colour Appearance (SDCM)		7-step ellipse		CCT 2650 – 2800 K	
CRI	3000K, 2700 K	80	80	80	80
	4000 K, 3500 K	80	80	80	80
	6500 K, 5000 K	80	80	80	80
Ignition requirement			The number of ignitions shall not be less than the claimed lamp life in hours	The number of ignitions shall not be less than the claimed lamp life in hours	The number of ignitions shall not be less than the claimed lamp life in hours
Guarantee to customer			2 year	2 year	2 year

The Swedish Strategy

To use minimum of resources to leverage a maximum amount of desired change i.e. to lower the program costs and to gain relatively quick promotion of CFLs by the retail trade STEM should approve and introduce the Danish and the British CFL performance specifications adopted by the Danish Electricity Saving Trust “**Elsparefonden**” and the British Energy Saving Trust **EST** as the Swedish national CFL performance specification and work jointly with Elsparefonden and EST in this context.

Furthermore, STEM should adopt mutual recognition of approved/rejected CFLs by Elsparefonden and EST. Whereby, not only the CFL performance specification but also the information on all CFLs approved, as well as rejected, for the Danish and British markets will be made known to the Swedish retailers and consumers. This information should be updated on regular basis. In the future, this cooperation should be extended to include ADEME (France) and NOVEM (The Netherlands) managed CFL programs.

It is worth mentioning that there are at least 94 manufacturers and 455 qualified CFLs that can potentially meet the Danish CFL performance specification. This information is based on the number of approved vendors and CFL models in the US by the DOE Energy Star Program.

In the future, as the European Union Energy Efficient Residential Lighting Initiative (ENERLIN) develops a “CFL Quality Charter” that guarantees for the end-user the CFL quality, STEM shall look into the possibility of adopting it as the Swedish national CFL performance specification together with Denmark and the UK.

New-to-the-marketplace CFL manufacturer / supplier (not already approved by Danish Electricity Saving Trust or the UK Energy Saving Trust) shall submit to STEM conformity of

performance statement. The technical documentation shall certify that all the above mentioned criteria have been met. Test reports from independent or captive, accredited laboratories (accredited by **DANAK**, the Danish national body for accreditation, Swedish Board for Accreditation and Conformity Assessment – **SWEDAC** and/or the United Kingdom Accreditation Service - **UKAS**) will be accepted by STEM.

The advantages

- International cooperation will provide access to CFL performance data from the partner countries.
- STEM will be able to use its limited “supervisory” resources at suppliers and products known to be non-compliant as identified by the partner countries.
- It will restrict under performing CFLs from moving from other European markets into Sweden.

The challenge

The challenge is to develop a framework for maximum exchange of information between STEM and its foreign partner institutions. What STEM needs to establish is what information gets to be shared between the partners e.g. lists of approved/ disapproved CFLs only or even hard data e.g. CFL test results.

8.1.1.2.2 Define Standard Procedures for Continuous Testing of CFLs According to the Quality Specification by an Approved Independent Organisation.

To ensure that CFL performance claims of vendors are accurate and in line with the CFL performance specification, STEM should perform frequently and at any unpredictable time, formal, off the shelf, random testing of CFLs, without manufacturer involvement, obtaining samples from a number of retail locations around the country and sending them to an accredited independent European laboratory for testing. Performance testing will include all main performance parameters mentioned in 8.1.1.2.1. The programme should be designed to test a substantial number of qualified products, with the target goal of testing 20% of the CFLs on the STEM’s approved product list every year.

Assessment of CFL performance is essential to track progress toward specific CFL program objectives and overall market transformation goals. Tracking and evaluation must be, therefore, an integral part of any program design, implemented to provide feedback into the market transformation process. It is believed that continuous CFL testing as a quality control mechanism will play a key role in maintaining CFL quality levels in the marketplace. Once the quality and efficiency requirements are met, it will allow STEM to develop a number of complementary demand stimulation programs.

In due time (an estimated three to five years) once the goals of raising CFL performance levels has been achieved and essential testing procedures have been established to ensure product performance and programme compliance, STEM could shift the costs for third-party testing of CFLs onto retailers, which, in turn, may shift it onto the manufacturers. Alternatively STEM may require manufacturers to fund independent, third-party testing, from the beginning of the program, to help provide quality control in the marketplace.

The Strategy

STEM should cooperate with the Danish DTI/Test Lab and the UK Lighting Association Lab, which have well established procedures for evaluating CFLs. Furthermore, Lighting Research Centre (US) has prepared a report “Energy Star Lighting Verification Program”, program for the evaluation and analysis of residential lighting (PEARL), semi-annual report, for the period of October 2003 to April 2004, prepared for the United States Department of Energy. This report includes the experimental procedure along with the description of apparatus used, equipment calibration process, and experimental methodology and research findings from the testing of CFLs.

8.1.1.3 How to Involve the Retailers?

8.1.1.3.1 The Problem

The retailers totally control the market for residential lamps. They are not convinced that it is in their interest to sell high quality energy efficient CFLs. They do not have the motivation to market CFLs, they lack incentives and they lack knowledge to sell CFLs.

Retailers employ a variety of different profitability targets. CFLs might be more profitable than incandescent lamps on Swedish Crowns per million-lumen hour’s basis. However, retailers may conclude that they are less profitable than incandescent lamps on a percentage mark-up or number of units sold per linear meter of shelf space per day (rate of inventory turnover).

The retailers are also unprepared to explain CFL terminology such as correlated colour temperature (CCT), run-up time, start-up time, wattage conversion or ballasts or why a compact fluorescent and an incandescent bulb having the same rated lumen output are perceived to produce different amounts of light.

Many of the new, cost competitive, niche CFL manufacturers that could secure retail space allotments lack the infrastructure to provide retailer training, inventory maintenance, and compelling point-of-purchase displays.

8.1.1.3.2 The Solution

National retailers such as Coop, ICA, Axfood (Willys & Hemköp) and IKEA must be encouraged by STEM to play a larger role in the CFL market transformation program. As the largest outlets in Sweden for lamps, they account for the majority of sales to Swedish customers. These retailers must be encouraged to follow the CFL performance specifications (adopted by STEM) towards their vendors and customers also ensuring that the marketed products are tested according to the STEM specification by the vendors before delivery.

The national retailers should be informed by STEM about the approved international CFL vendors operating in the US, Denmark and the UK market places. It will greatly help retailers to choose quality CFLs at competitive costs and broaden the supplier base on the market.

STEM should also prepare trade lists with contact information about the major buyers of light sources in Sweden (retailers) and communicate it the DOE Energy Star, UK market transformation and the Danish CFL program approved vendors. This will also help to broaden the CFL supplier base and increase competition in the Swedish marketplace, thereby, lowering the CFL prices for the consumers.

STEM can assist in increasing the marketing capabilities of the retailers by providing visible, attractive, in-store point-of-purchase displays and brochures. STEM can also help educate the retail sales staff through training and field visits by Energy Advisers, lighting consultants and/or manufacturer representatives. STEM can also help in designing the product packaging in a way that it functions as a powerful tool to convey product benefits.

STEM, together with lighting fixture retailers, could target few key market segments to increase product availability, improve quality, and reduce long-term purchase price, for example, under cabinet lighting in kitchens, outdoor lighting with 40W, 50W and 60W floods, flush fittings for lower ceilings, security lighting, stairwells and landings and Wall washers. The aim should be to introduce CFL lighting technology in niche applications where benefits are clearly defined, and consistent with buyer needs.

STEM should encourage the major retailers to move CFLs from temporary dump bins to permanent shelf locations. To move CFLs from the less desirable knee-level display shelves to the more desirable eye-level shelves, and to carry more models of CFLs, and to carry CFLs year-round instead of just during promotions.

STEM should also help consumers see new CFL technology in retail outlets, for example, by encouraging lit in-store displays. Whereby, the customers can see how the colour of the light for a certain CFL would be.

The regional energy offices can coordinate regional programs with retailers, and help conduct promotional activities to encourage the sale of CFLs; typical activities would include product merchandising— fashioning product displays, providing end-cap displays, verifying product pricing, ensuring product availability, and generally making the products more visible to shoppers—as well as employee training, on-site promotions, and reporting and responding to signals in the marketplace.

In the future, STEM, through its participation in the European Union Energy Efficient Residential Lighting Initiative (ENERLIN) will develop a “CFL Retailer Information Package”, catering to the Swedish market circumstances.

8.1.1.4 Broadening CFL availability

8.1.1.4.1 The Problem

CFLs are not available in Sweden at all places where people can buy standard incandescent lamps. The independent lighting stores and retail outlets cannot compete with major retailers like IKEA on price where CFLs are concerned. The major lamp manufacturers are not interested in supplying small retailers so the small retailers have to purchase through wholesalers where the prices in most cases are much too high. This is an issue which involves both variety and pricing.

8.1.1.4.2 The Solution

STEM should strive to make CFLs available through market channels where incandescent lamps are typically purchased e.g., at grocery stores including gas stations and outlets such as 7-11.

STEM should approach the UK Lighting Association to act as a buyer to help Swedish smaller retailers obtain a greater variety of CFL products at improved pricing. The UK lighting Association would enter into contracts with approved larger manufacturers of CFLs on behalf of the smaller Swedish retailers. The UK Lighting Association is recommended for this task as it is already acting as one large account, annually buying between 5 - 10 million CFLs, on behalf of smaller UK retailers. Adding Swedish retailers to the UK purchasing program will be a more cost effective alternative to creating a Swedish centralised purchasing organisation or asking the Swedish Lighting Industry Association (Belysningsbranschen) to undertake this task.

Practically STEM should work out a deal with the UK Lighting Association and then make their price and product list available to the Swedish small retailers.

It may be added that to ensure quality compliance, the CFLs supplied by the UK Lighting Association are regularly and randomly tested by the laboratory owned by the Association.

8.1.1.5 How to help the customers in choosing appropriate CFLs

8.1.1.5.1 The Problem

A consumer has no way of knowing how to separate a good quality CFL from a bad quality CFL in the Swedish marketplace.

8.1.1.5.2 The Solution

STEM should set up a web page to inform the general public about the approved (good quality) and disapproved (bad quality) CFLs as well as who markets them. The web page should be rapidly updated.

In retail outlets at the point-of-purchase, STEM should encourage and help retailers to display CFLs by application and purpose rather than by technology or wattage i.e. be more application-focused. If a customer goes to the store seeking a bulb for a reading lamp, for example, he may be presented with good/better/best options that correlate to longer product life and greater energy efficiency. This strategy is expected to increase CFL sales compared to the current strategy of placing all CFLs in a single part of the store, regardless of their light output, shape, or application.

As CFL manufacturers are transitioning from boxes to blister packs, a move intended to reduce breakage in shipping, the possibility of providing more front-side surface for product information is created.

Denmark has developed specific information material catering to residential lighting, which should be evaluated and adapted to Swedish circumstances.

In the future, STEM, through its participation in the European Union Energy Efficient Residential Lighting Initiative (ENERLIN) will develop a “CFL Consumer Information Package”, catering to the Swedish consumers of CFLs.

8.1.1.6 Availability of Appropriate CFL Based Lighting Fixtures

8.1.1.6.1 The problem

There is a lack of well designed and efficient CFL based fixtures on the Swedish market place.

Furthermore, the ballast for the CFL is either built into the luminaire or the consumer must purchase replaceable ballast that plugs into the luminaire's line-voltage socket. The lighting fixtures that use dedicated, pin-based CFLs with a separate ballast, can be economically, optically, and thermally optimized, while screw-based CFLs are a compromise placed in fixtures intended for use with conventional incandescent sources, and require the user to discard both ballast and lamp every time one or the other fails. The dedicated CFLs with separate ballast allow a pin-based bulb (glass part) to be replaced when one burns out. The ballast and base can generally be reused for about five bulb replacements (most ballasts are rated at 50,000 hours). Using dedicated CFLs with separate ballast can, therefore, substantially lower overall system costs for the consumer.

There is, however, the need for a standard CFL-line-voltage socket design. The problem is that no design standard exists for the line-voltage socket. As a result, there is no standard for the ballast base that connects with the socket.

Without standards for the socket and ballast base, ballast products are not interchangeable, therefore, when the ballast dies, consumers have to go through the hassle of finding the correct product that fits their fixture's particular socket or throw away the fixture. Difficulties with buying replacement parts may limit consumer acceptance of energy-efficient light fixtures.

8.1.1.6.1 The Solution

8.1.1.6.1.1 For the first issue

STEM should document and spread information about good CFL fixtures available on the Swedish market to the consumers. This, however, requires an evaluation of the fixtures being marketed.

STEM should also document and pass over information to the Swedish consumers and lighting retailers from the first & second European Design competitions (EDC) conducted by the European Union to identify attractive design solutions aimed at the residential markets for lighting fixtures dedicated to pin-based CFLs. European Union picked 27 models in its first competition.

STEM may also pursue the lighting design competition conducted by the American Lighting Association, the Consortium for Energy Efficiency, and DOE that was started in 2003 and has received positive media and enthusiastic participation by some lighting manufacturers. This, however, requires an adaptation to European standards by the US lighting manufacturers to be realized practically.

In the future, STEM, through its participation in the European Union Energy Efficient Residential Lighting Initiative (ENERLIN) will develop a "CFL Lighting Fixture Information Package", catering to the Swedish consumers of CFLs.

8.1.1.6.1.2 For the second issue

The U.S. Environmental Protection Agency (EPA) and the American Lighting Association (ALA) have helped the industry to develop a line-voltage socket and ballast base design for compact fluorescent lamp (CFL) fixtures. The line-voltage socket is suitable for residential luminaires of 26 watts or less, including floor and table lamps, wall fixtures, chandeliers, and

ceiling fans. The socket design maintains an open protocol and is available to the public without any royalties.

STEM should through cooperation with the U.S. Environmental Protection Agency (EPA) look into the possibility of introducing the same line-voltage socket and ballast base in the Swedish/European market place.

8.1.1.7 How to lower CFL prices in the Swedish marketplace

8.1.1.7.1 The problem

The major light source vendors maintain a high price low volume CFL marketing strategy in the Swedish marketplace. The major vendors argue that there is a direct linkage between higher prices and higher performance. This has, however, not been borne by studies conducted by Test Lab (Sweden), Lighting Association (UK) and US DOE PEARL programme.

The price (fob) of a CFL, which replaces a 60W incandescent bulb, and which meets the European Quality Charter and the US DOE Energy Star specification, is between Euro 0.6 – 0.7 (corresponding to between 6 and 7 Swedish Crowns), when delivered by the Chinese manufacturers.

8.1.1.7.2 The solution

STEM should activate major housing societies e.g. HSB, Familjebostäder, Senäte Fastigheter, Svenska Bostäder etc. to join in a direct procurement of CFLs from approved manufacturers or through the British Lighting Association for use in common area and outdoor lighting applications as well offering CFLs to their tenants.

STEM should activate major utilities e.g. Vattenfall and E-ON to procure and offer CFLs to their residential customers at cost.

9. Consumer Concerns on CFLs

The consumers are concerned about light quantity issues (brightness, start time and lumen maintenance), light quality issues (light colour and colour consistency between different lamps), cost issues (price, efficacy and life predictability) and usage issues (fit/application). Some of these issues are discussed below.

9.1 Colour of the Light

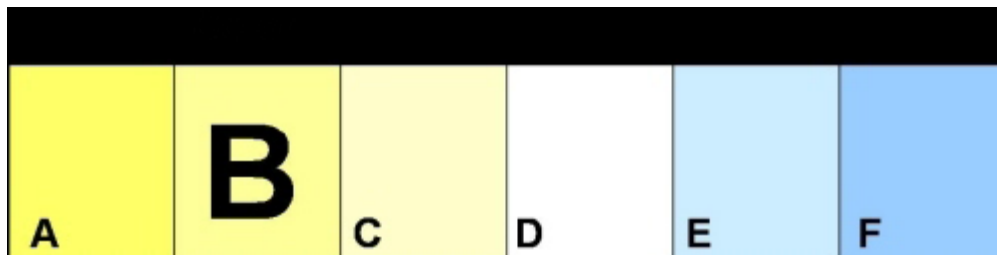
One of the key issues of CFLs has been colour. People have strong preferences for the colour of light, and they want to select the right colour to complement their home decor. They also want consistency in colour and for lamps rated as the same colour to appear the same, especially for those used in the same room. Consumers have complained that they cannot meet their colour needs with many of the CFLs on the market today. Consequently, to address the colour problem there is the need for the development of a colour tolerance zone, starting, for example, with CFLs having CCTs of 2700 K and 3000 K as a first step. The industry must establish the size and shape for a colour tolerance zone that will be ‘do-able’ for manufacturers and ‘acceptable’ to consumers.

Swedish consumers are believed to prefer “warmer” (yellowier) colour that more closely matches incandescent. However, more consumer research is needed to determine end-user compliant and exact colour preference.

It may be added that if there is a change in the specification for colour for CFLs, it may have an impact on lamp efficacy, since tighter colour control can lead to slight decreases in efficacy. Significantly tighter control will also result in increased production and product costs.

There are four major factors which cause variability in colour. First, different manufacturers use different phosphor mixes which results in visible colour differences between manufacturers' products. Second, a given manufacturer may make multiple wattages of CFLs, anywhere from 9 to 42 watts, and changes in wattage result in shifts in CCT. Third, poor quality control in specifying phosphors and manufacturing the lamps can lead to variations in colour even when one has a single manufacturer. Fourth, the internal temperature of the lamp affects the CCT so covered CFLs and uncovered CFLs will appear to have a different CCT unless the manufacturer makes specific adjustments to make them match.

In the future the CFL manufacturers may be asked to add a colour label to packaging to help consumers identify whether the CFL produces a warmer or cooler light.



9.2 Indoor and outdoor CFL applications

There is a need to separate indoor and outdoor CFL applications. Operating fluorescent lamps in cold or hot environments will lead to reduced light output and reduced efficacy.

In certain indoor applications amalgam based CFLs are needed i.e. in recessed cans to handle high temperatures.

According to studies conducted by the US DOE, there is a clear indication that covered lamps (CFLs made to look like incandescent bulbs) have unstable luminance maintenance (luminance drops fairly rapidly after 1000 hours) and lower efficacies vis-à-vis bare CFLs. This is due to an increase in lamp operating temperature. However, in Sweden, due to a relatively colder climate, the covered lamps may perform well in outdoor applications.

9.3 Lamp size

Typical 60-100 watt incandescent lamps are no more than 13.4 cm long, while standard CFLs are longer than 15.2 cm. Therefore, sub-CFLs have been developed. No more than 11.4 cm long, sub-CFLs fit into most incandescent fixtures. The sub-CFLs are preferred by the consumers for their aesthetics and better fixture fit. However, sub-CFLs are less efficient vis-à-vis standard CFLs. Compactness traps light and thereby reduces the amount of available useable light. STEM should not discourage the use of sub-CFLs against customer preference.

9.4 Starting temperature

The minimum and maximum temperatures at which the lamp will reliably start need to be communicated to the consumer.

9.5 Lamp efficacy

The consumers need to be informed that lower wattage CFLs have lower efficacies and higher wattage CFLs have higher efficacies. A bare CFL under 15W is around 45 lumens/ Watt, whereas lamp over 15W is around 60 lumens/ Watt. Furthermore, covered bulbs have lower lumens per watt. Generally lumens/ Watt for covered lamps are as follows: less than or equal to 14 watts: 40 lumens/ Watt; 15-19 watts: 48 lumens/ Watt; 20-24 watts: 50 lumens/ Watt; greater than or equal to 25 watts: 55 lumens/ Watt.

9.6 Dimmable CFLs

Many homes are moving toward automated systems, including lighting control. The area between lighting and control is beginning to melt together, but unfortunately many individuals in the control business are attempting to provide lighting design without adequate knowledge of lamps. There is a need for the development of a testing protocol for dimmable CFLs. The protocol could, for example, require the test to dim the CFL down to 30% light output then back up to 100% with a dimming/lumen maintenance requirement inserted into the test procedure. There is a need to look at performance issues, especially at lowest wattage rating. Experience has shown some CFL products become unstable on low wattages.

10. Utility issues

10.1 Power quality implications of CFLs

The proliferation of CFLs is believed to result in an increased growth of so-called non-linear loads from a utility point of view. There are increasing concerns by some utilities on the effects from such loads on power quality.

While at the highest levels, utilities are concerned with distortion to the voltage waveform that they supply to their customers, they are also concerned with the effects of non-linear loads on their distribution infrastructure, which can include capital equipment. Some are concerned with disturbances that may occur within the premises of their customers since such customers may attempt to fix the blame for local interaction problems on the power quality as supplied by the utility.

However, non- PF corrected (typically 0.5) CFLs draw about half the RMS current as their full wattage incandescent counterparts, CFL loads reduce current losses that occur throughout the distribution infrastructure, both on the utility side and within the user's premises. By switching over to CFLs, power use is reduced to 25% of the equivalent incandescent bulb, "I squared R" distribution losses throughout the electrical infrastructure are also reduced. Whereas, harmonic currents, THD (f) are greater than an incandescent lamp, typically 150%, with some as high as 175%. Harmonic currents are on the order of 15ma per watt.

CFLs draw much less total RMS current than the incandescent lamp it replaces. This means that if we only consider PF, a low PF CFL actually has better "power quality" from an RMS current demand perspective than the original incandescent lamp with its 1.0 PF! Furthermore, the CFL PF could degrade all the way to 0.3 and still draw less RMS current than the original incandescent lamp it replaced.

The only way PF would be an issue would be if CFL manufacturers produced lamps with the same equivalent wattage level as the incandescent lamp it replaced.....however this would provide no user benefit and would not be accepted. Consequently, Low PF is not an issue for residential screw-in CFLs.

Even with a very high degree of CFL penetration in Sweden, the average power level of CFLs sold into residences will be approximately 100 watts. This is lower or equivalent than a modern TV or PC. The worst case third harmonic current associated with such CFLs will be approximately *800 milliamps*. There is no direct evidence that such harmonic currents circulating within a local residential branch circuit are problematical. Other consumer products have circulated such currents for decades. There is no direct evidence that even aggregate CFLs produce aggregate harmonic currents that have caused problems with local low voltage utility transformers that serve multiple residences, or that such harmonic currents result in unacceptable voltage distortion on either the primary or secondary side of the residential service transformer, or that such CFL harmonic currents from residences cause unacceptable THD(V) levels at locations upstream from the residence.

Furthermore, the addition of other types of loads (from TV, PC, microwave ovens, laundry machines etc.) commonly found in residences dramatically swamps out or dilutes any possible component of Harmonic current provided by the lower power CFLs due to phase angle cancellations.

11. Targeting Customer groups

Multifamily housing and senior citizens are two markets perceived to be potential drivers for energy efficiency in residential fixtures. Apartment owners who foot the bill for outdoor and common area lighting would see the gains of large-scale replacement of incandescent lamps with energy-efficient CFL lighting.

It is also thought that older consumers would be interested in the inherent safety that longer lasting bulbs would provide by requiring less frequent light bulb changes and providing higher amounts of light at lower wattages. As people get older they need relatively more light to perform even simple mundane tasks.

12. Program organisation

TEST LAB at STEM will provide overall programme management, defining programme scope, delivery and timing. The Lab shall be responsible to work with stakeholders to establish product performance specifications, approve testing processes, monitor compliance with those specifications, inform the general public, and provide labelling and educational support for compliant products.