EcoShopping - Energy efficient & Cost competitive retrofitting solutions for Shopping buildings

Co-funded by the European Commission within the 7th Framework Programme.
Grant Agreement no: 609180.
2013-09-01…2017-08-31 (48 months).

Appendix 12.

Lighting and Daylighting SWOT Analysis

1 Introduction

This document aims at analysing the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the main Lighting and Daylighting technologies categorized and listed in Table 1.

All the analysis toward the listed materials will be presented in tables in the following sections.

Table 1 Lighting and Daylighting technologies

LIGHTING AND DAYLIGHTING TECHNOLOGIES	
LIGHTING	COMPACT FLUORESCENT LAMPS
	LED LIGHTING
	OLED LIGHTING
	MICROPLASMA LIGHTING
	SULFUR PLASMA LIGHTING
DAYLIGHTING	FIBER OPTIC LIGHTING
	NATURAL LIGHT ILUMINATION SYSTEM (NLIS)

2 Lighting technologies

2.1 SWOT analysis for compact fluorescent lamps

SWOT ANALYSIS	COMPACT FLUORESCENT LAMPS[1]
Strengths	• Elimination of prolonged lamp outages and reduced maintenance costs. • Improved lamp light output (four to five times more per watt than comparable incandescent lamps). • Longer rated life (10 to 20 times longer than for incandescent lamps). • Replacing incandescent lamps with CFLs would reduce energy use 75 to 80%. • Reduction in energy costs. The effect on GHG would vary greatly by country due to difference in electricity generation. CFLs used three hours per day can have a payback period of less than one year. • Increased efficiency of CFLs reduces the lighting heat addition, offsetting the energy and greenhouse gas benefits of conversion to more efficient lighting sources (assuming the electricity generation mix remains the same). • Warm white CFLs are available as well.
Weaknesses	• Initial Cost is greater than comparable products. CFL bulbs can range from €3 to €12 depending on their type. This is much more than typical incandescent bulbs, but their lifetime and energy savings are significant. • CFLs are ill-suited for recessed and enclosed fixtures • A typical CFL contains a very small amount (5 mg) of mercury, a toxic substance. Without an effective recycling program it is assumed CFLs will end up in landfills, which is a potential environmental issue if CFL use increases substantially. Conversely, electricity generation, particularly coal-fired, also releases mercury into the environment. Therefore reduced demand for coal-fired electric generation could reduce the amount of atmospheric mercury emissions. These effects represent both a cost and benefit; a fair comparison of these relative effects is required to evaluate the overall environmental effect of this regulation. • Consumer surveys and laboratory tests report premature CFL failure due to rapid-cycling and other operating conditions such as elevated temperatures. It is likely that increased use may result in a higher number of CFLs operating under less than ideal conditions. • Such use could lead to a higher number of CFL failures, thereby increasing costs to the consumer due to premature replacement as well as increasing the amount of mercury disposal relative to ideal lamp operation.
Opportunities	• Primary replacement technology because they already meet the proposed requirements and are a “drop-in” replacement for general service incandescent lamps.
Threats	• There are emerging technologies (LEDS, OLEDS) that have

[1] CANMET, 2004. LRC, 2003.
Energy Star, 2007; Parsons, 2006: 9. LRC, 2003: 2-5; O’Rourke & Figueiro, 2001: 30

	more energy saving potential. As these new emerging technologies go cheaper, fluorescent lamps will lose its interest and become obsolete.

2.2 SWOT analysis for LED lighting

SWOT ANALYSIS	LED LIGHTING[2]
Strengths	• Low energy consumption – retrofit bulbs range from 0.83 to 7.3 Watts • Long service life – LED bulbs can last up to 50,000 hours • Durable – LED bulbs are resistant to thermal and vibrational shocks and turn on instantly from -40C° to 185C°, making them ideal for applications subject to frequent on-off cycling, such as garages and basements • Directional distribution of light – good for interior task lighting • No infrared or ultraviolet radiation – excellent for outdoor use because UV light attracts bugs • Safety and environmentally conscious – LEDs contain no mercury and remain cool to the touch, because LEDs generate much less heat compared to other lighting systems. • Fully dimmable – LEDs do not change their colour tint when dimmed unlike incandescent lamps that turn yellow • No frequency interference – no ballast to interfere with radio and television signals • Range of colour – LEDs can be manufactured produce all colours of the spectrum without filters, they can also produce white light in a variety of colour temperatures
Weaknesses	• Very expensive • Does not perform well under high wattage applications yet • Still in development phase of technology • High glare effect • High quantities of aluminum used for heat sinks • Re-lamping expensive – the whole LED arrays needs to be replaced • Single LED failures create negative visual effect
Opportunities	• Could replace all applications of light fixtures after some years of development • Continuing Energy-saving as LED light enrichment protection appeal for industrial and commercial lighting • Online opportunities worldwide • Government policy support in many European countries
Threats	• Still under development and may not reach reasonable price levels for years • Domestic market purchasing power of customer • The biggest limitation to LED for common residential use is the cost of manufacturing due to still-limited production runs. Manufacturers claim production will increase considerably in the near future, further lowering prices. Currently, there is a limited number of LED fixture manufactures, but this is changing. Retrofit bulbs range from €20 to €60 for night lights and small lamps. • The development of new technologies like Microplasma lightning

[2] http://eco-system.in/home/products/4-led-lighting-systems

2.3 SWOT analysis for OLED lighting

SWOT ANALYSIS	OLED LIGHTING[3]
Strengths	• OLED material is very light weight, thin and transparent. • OLEDs can be printed on a thin layer of film or even a sheet of paper, so its flexibility and small size is a determining advantage. • Displays applying OLEDs are generally brighter compared to other display solutions • OLED displays are more energy-efficient in general, and have a wider viewing angle compared to other display solutions. • OLEDs are easier to produce and can be made to larger sizes. Because OLEDs are essentially plastics, they can be made into large, thin sheets.
Weaknesses	• OLEDs are not used for lighting purposes at the moment. The brilliance of the diodes are not high enough for this application. • OLEDS slowly lose their light-emitting properties. The current materials use dare expected to last between 10,000 and 14,000 hours although this is expected to improve. Some would say this is long enough as it implies a screen usage of 5.5 years for a 7 hour per day usage (Conti, 2008) • Manufacturing processes are expensive right now. • Water can easily damage OLEDs.
Opportunities	• OLEDs are the fastest growing flat panel display technology today, with Europe playing a key role as a technology developer. • Success for OLEDs depends on two key technical advances: first, the operating lifetime, which is based on the stability of each colour; and second, the production process. If the latter can be developed, with consistent high quality at low cost by using low cost printing and room temperature processes, that combination could take unit costs well below other products. • NanoMarkets predicts that from zero in 2008, the general purpose market for printed lighting will grow to about \$119 million in 2010 and to over \$1.5 billion in 2014, consisting mainly of OLEDs.
Threats	• The market for lighting is potentially enormous but more uncertain. OLED lighting seems likely to remain a niche product for the foreseeable future, owing to investment in existing incompatible infrastructure. • Attempts have been made to use it as a main source of light: the first one was by Osram in 2009 November, but the Orbeos light panel, besides the above mentioned problems, had the disadvantage of high price as well. • OLEDs may not be suitable for main source of lighting at the moment; it allows a new range of unconventional lighting solutions, hopefully to appear on the market within a few years. Novaled OLED panels are a good example for this - these panels are transparent layers applied on a window for instance, letting in sun light during the day as a regular window, but serving as a source of light during the night. This background light solution can be obtained other ways as well. Since OLEDs can be printed on any thin layer or sheet, they are an alternative solution for wallpapers as a background light. OLED wallpapers - which are

3 http://www.ledcentre.uk.com/newsletter/oleds-in-lighting.html

	the combination of art and technology - are due to appear on the market in 2012. • These peculiar solutions of lighting are going to revolutionize our idea about home or commercial lighting, hopefully in the near future.

2.4 SWOT analysis for microplasma lighting

SWOT ANALYSIS	MICROPLASMA LIGHTING[4]
Strengths	• The lighting can be any shape or colour. • Flexible sheets • It is mercury-free, contains no toxins, and environmentally friendly • Ultra thin (less than 3mm) and flat form factors that can be flexible and formed, unlike fluorescent and HID sources • Eliminates the need for external reflectors to control the light distribution • Longer lasting light source: Offers long life of up to 50,000 hours • Surpasses functional LED system efficacy • Operates cool and generates less heat • Its plastic, glass and aluminum contents are easily repurposed and recyclable.
Weaknesses	• Currently, the largest arrays produced are 6 sq. in. • Because of the rate of production, the MCA is not cost-competitive with current lighting options
Opportunities	• Hold considerable promise as the next generation of lighting technology • US Congress mandated that incandescent lights be phased out in 2014. EU will possibly act similarly.
Threats	• It is not a fully developed technology

4 http://www.informlightworks.com/?p=146

2.5 SWOT analysis for sulfur plasma lighting

SWOT ANALYSIS	SULFUR PLASMA LIGHTING[5]
Strengths	• Sulphur Plasma lamps are between 25% - 100% more efficient than any other artificial source of high quality white light. • The light is true full spectrum daylight and thus features all of the qualitative benefits of sunlight. • The light is almost 100% PUR and thus perfect for photosynthesis. • Light can be efficiently distributed over large spaces, superior to all arc-based lamp technology in every sense, and costing no more than lamps which are used extensively in the Film and Theatre industry. • Unlike all other artificial light sources, the light output and colour (light output quality) does not degrade over time and it is fully dimmable down to 30%. • It contains no lead, unlike most other lamps, no mercury, unlike all fluorescent lighting and no arsenic unlike most LEDs (Gallium Arsenide). • The lamp's output is low in infrared energy, and less than 1% is ultraviolet light. As much as 75% of the emitted radiation is in the visible spectrum, far more than other types of lamps.
Weaknesses	• Limited life – Magnetrons had limited lives. • Large size • Heat – The sulfur burnt through the bulb wall unless they were rotated rapidly. • High power demand – They could not sustain a plasma in powers under 1000 W.
Opportunities	• Suitable for indoor agriculture and indoor growing processes
Threats	• Its market is restricted to very specific needs

5 http://www.plasma-i.com/plasma-email3.htm

3 Daylighting technologies

3.1 SWOT analysis for fiber optic lighting

SWOT ANALYSIS	FIBER OPTIC LIGHTING[6]
Strengths	• Deliver natural light to spaces deep in a building. • Distributed day lighting through optical fibers is a high-tech approach to making use of natural light. • On the roof or an outside wall, there's a one-meter-square collector that track the sun as it moves across the sky. • The SP2 uses about 2 watts of electricity to operate this tracking, which is controlled by a photosensor and microprocessor. • The cables can be run through interior wall cavities, ceiling plenums, or wiring chases, and their bending radius can be as tight as two inches • The Fiber Optic Lighting can take the form of spotlights, fairly conventional-looking ceiling fixtures, and some hybrid fixtures that include both day lighting and high-efficiency fluorescent lighting. • The colour of the light changes throughout the day. In the early morning and late afternoon, it can be distinctly orange, while in the middle of the day, it can be quite blue, which gives the light a cool feeling.
Weaknesses	• The greater the length from the light source, the greater the light loss: at 33 feet (10 m) 64% of the light is delivered; at 65 feet (20 m), only 40%. • The system is quite expensive, with a system starting at about €8,000 for one SP2, four optical-fiber cables, and four fixtures, plus installation. • It can only be used in the daytime, and in certain daylight conditions
Opportunities	• If prices come down, this could become a practical strategy in the future.
Threats	• Not suitable for the lower floors • This technology is not easily available commercially in Europe

6 http://www2.buildinggreen.com/blogs/fiber-optics-daylighting

3.2 *SWOT analysis for natural light ilumination system (NLIS)*

SWOT ANALYSIS	NATURAL LIGHT ILUMINATION SYSTEM (NLIS)
Strengths	• **Collecting:** There are two layers of the prismatic element and the innovative element improve the sunlight leakage and loss problem • **Coupling:** The new coupler is with high transmittance efficiency and suitable to assemble on the lightpipe • **Transmitting:** The efficiency of light pipe is higher than fiber on the long distance transmission. • **Emitting:** The new emitting component can used on light pipe and LED both to provide steady indoor illumination
Weaknesses	• **Collecting:** The innovative element has to coat AR coating. It will increase the cost and difficulty of mass production • **Coupling:** If the light source distribution is Lambertian (like LED), the transmittance will be lower. • **Transmitting:** The flexibility of light pipe is lower than fiber • **Emitting:** The weight is heavy and dimensions are large.
Opportunities	• The weight of PMMA is lighter than conventional glass material. • PMMA is easy to manufacture and the cost is cheap. • It is also much easier to mass production than glass.
Threats	• The hardness is low, easy to get scratched. Therefore, a cover glass should be used on the LightBrick module to avoid scratch and dust. • The guarantee period of PMMA is shorter than Glass. The guarantee period experiment is still on going. However, the default period of PMMA material is 15 years.

4 Conclusions

The integration and development of lighting technologies are not considered due to the large amount of research effort that the previous projects carried out, instead, this project will pay more attention to the daylighting technologies. In the renovation of the shopping center of Sopron, lighting technology is not considered either. However, this study of the lighting technologies will serve as an assessment of retrofitting solutions and can be used as a baseline for users who wants to implement it on his project. Specifically, according to the SWOT analysis of the available alternatives of lighting technologies, OLED technology has an enormous potential market in a long term of view, but at this moment they are not mature and cost effective enough to be used for lighting purposes. For the LED technology, in fact it is the most used technology in lighting refurbishment projects, since it has several advantages, such as a low energy consumption and long service life, but the price and the medium-long ROI could be subjects that the project owner should consider. As times go by and improvement in technological development, the LED will have a higher potential compare to other alternatives, the price is envisioned be reduced reasonably in a short term.

As the natural lighting technologies are concerned, the daylighting is considered the best source of light during daytime in buildings because it can save energy in place of using artificial lighting, which represents a major component of energy consumption in commercial buildings. Many research studies have focused on natural light illumination as a means of saving energy and creating healthy lighting.

Today, most daylight collectors use dynamic concentrators, but these designs are too expensive to be cost effective, need building remodeling to install and the existing daylighting technologies are impossible to expand to fulfill increasing indoors illuminance requirement.

The NLIS system developed by NTUST can be adjusted according to the illumination needs by increasing the number of cascadable light collecting units. In addition, the novel system is made up of PMMA material and as it is easy for mass production and thus the manufacturing costs can be reduced for large scale production.

The NLIS system will be an all-optical daylight guiding system with modular structure which allows the flexibility to design and install the system in any part of the commercial buildings so to gain the optimization of energy efficient lighting systems. The efficiency of light pipe is higher than fiber on the long distance transmission.
During the night or overcast day, the system can be integrated with the artificial lighting system to simulate the natural light and be robust to be a light provider regardless of outside lighting situation. Furthermore, taking the advantage of light's reciprocal property, during night time when there is no sunlight to collect, the system is transformed to become an energy-saving artificial lighting system by transmitting the indoor light outside so the surface of the devices used for light collection emits, which can be served as exterior lighting fixtures of commercial buildings without using extra spot lights.