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Editorial

Papers

Conferences and symposiums

Anniversary

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The journal **INGINERIA ILUMINATULUI - Lighting Engineering** - is affiliated to the CNRI - Romanian National Committee on Illumination, member of the CIE - Commission Internationale de l'Eclairage. It has a scientific presentation and content, targeted to the continuing education in the lighting field.
The objectives of the journal consist of the presentation of the results of the lighting research activity, the dissemination of the lighting knowledge, the education of the interested people working in public administration, constructions, designers, dealers, engineers, students and others.
The responsibility for the content and the English language of original paper rests solely with its author. The opinions of the authors, references and collaborators are personal and do not necessarily coincide with those of the editor.

SUSTAINABLE LIGHTING

Dr. Florin POP,
Consultant Professor

Sustainable Lighting was the major topic of the 5th International Conference on Lighting ILUMINAT 2009 held in Cluj-Napoca, Romania. A short half day Conference celebrates my 65 years and retirement from the university teaching activity. Fortunately, the Conference was honored by the presence of Professor Wout van Bommel, himself just before retiring from Philips Lighting, after 40 years devoted to Lighting.

The paper of **C. CIUGUDEANU** received The Award of the Best Paper of Ph.D. Student (there where two awarded papers). Its topic is related to the tubular daylight guidance system and its application in a residential building. A light pipe was mounted inside a 4.2x3.5 m room on the first floor of the building. The house is part of a duplex situated in Cluj-Napoca. Illuminance measurement was carried out using a standard light meter. Some simulations were made for the same room using the Dialux Software. There were taken into consideration the four seasons, the 12:00 hour of 15 of January, April, July and October, plus the exact latitude and longitude of the building. The TDGS was assimilated with a roof light but the direct sun light was not taken into consideration for the calculation. Also the roof peek shadow was not considered for the simulation.

The paper of **Anca D. GALAŞIU, G.R. NEWSHAM, C. ŞUVĂGĂU, D.M. SANDER,** reprinted with permission, is the result of an impressive research, a field study on lighting control systems for open-plan offices. Data were collected from 86 workstations over a year to examine the energy savings and power reduction attributable to the controls, and how the controls were used.

A particular direct-indirect lighting system saved 42% in lighting energy use compared to the static ceiling-recessed system it replaced.

Three controls were used - integral occupancy sensors and light sensors (daylight harvesting), as well as individual dimming control accessed through occupants' computer screens.

Results indicate that the lighting system generated substantial energy savings and peak power reductions compared to a conventional fluorescent lighting system installed on a neighbouring floor.

If the three lighting controls systems had been installed separately, occupancy sensors would have saved, on average, 35% if used alone, light sensors (daylight harvesting) 20%, and individual dimming 11%.

The three controls combined saved 42 to 47% in lighting energy use compared to the same lights used at full power during work-hours; this translated into overall savings of 67 to 69% compared to the conventional lighting system.

The average effective lighting power density was reduced at the only 3 W/m^2.

The paper of **G. ZISSIS, Patrizia PISTOCHINI, Simonetta FUMAGALLI** gives some insight on results obtained by this 3-year project that execution has been achieved in December 2008. The results presented are mainly concern the analysis of CFL market barriers and especially quality issues as well as dome examples of CFL promotional campaigns that have been undertaken in order to discard the barriers.

An important task in the frame of EnERLIn was to understand why end-user avoids (or dislikes) CFLs for residential use. Analysis of possible barriers to implement CFL´s has been carried out in order to understand the human mechanism regarding willingness and avoidance to implement CFL. The result showed that around 30% households do not want to have CFL´s in their home and that reasons for not having CFL´s are many.

A CFL-Quality monitoring has been carried-out in ENEA (IT) and UPS (FR). The tests aimed to evaluate the ageing of CFL in a simulated real-use environment, and are based on EU standards and Quality Charter. Tests are performed on a number of CLFs (the most common powers) form different brands, under different environmental conditions (i.e. in climatic chamber).

EnERLIn consortium produced databases with high quality CFLs and fixtures. Both databases are searchable and accessible via the project web page.

The most important outcome from EnERLIn project was the design and testing of various CFL national promotional campaigns - Germany, Latvia, Italia, Poland, Sweden, Bulgaria, Czech Republic, Romania and Hungary. The paper presents specific approach and achievements for each of these national campaigns.

TUBULAR DAYLIGHT GUIDANCE SYSTEMS - ENERGY SAVING POTENTIAL IN RESIDENTIAL BUILDINGS IN ROMANIA

Călin CIUGUDEANU[1], **Florin POP**[2],
[1]Ph.D. student, [2]Professor, Technical University of Cluj-Napoca, Romania

Abstract. *Traditional vertical window can provide adequate daylight within about six meters of the window. Daylight levels decrease asymptotically with distance from the window so that a disproportionate amount of daylight/solar gain must be introduced into the front of the room to achieve small increases in daylight at the back. A number of systems exist to redirect daylight into areas of buildings that cannot be lit by conventional glazing. One major generic group is known as 'beam daylight' - redirects sunlight by adding reflective or refracting elements to conventional windows. The second major group is known as 'tubular daylight guidance systems (TDGS)'. These consist of a light transport section with, at the outer end, some device for collecting natural light and, at the inner end, a means of distribution of light within the interior.*

TDGS daylight guidance systems are linear devices that channel daylight into the core of a building. The nature of the systems and the factors influencing the costs and various benefits that contribute value are identified. Lighting systems in residential buildings, lit by electric lighting and daylight guidance, were surveyed. Data on the physical characteristics of the systems, lighting conditions achieved, and user views were collected. The results formed the input to a cost and value analysis which permitted the economic limits of the systems to be evaluated. Some evaluations were made about the energy savings and the environmental benefits.

Keywords: *tubular daylight guidance systems, potential savings, residential buildings*

1. Introduction

Why is daylight not always a primary consideration in building design? There seems to be some common barriers, throughout the world, that hinder appropriate integration of the daylighting aspects: lack of knowledge on the performance of daylighting systems and lighting control strategies; lack of appropriate and user friendly daylighting design tools; lack of evidence of the advantages of daylighting [1].

The architectural volumes are evaluated by shades and light, either natural or artificial. Le Corbusier said about architecture that it is "the learned play, correct and magnificent of the volumes reunited under light". The underground spaces (metro, commercial galleries, passages) are architectural expressed in a theatrical manner, with the artistic effects realised by the artificial light of projectors, by the dynamics of environment, by the esthetical effects.

Windows – through which daylight is introduced to the interior, where the light is modified and controlled, and from which the views out beyond the building are obtained – are at the heart of the matter. There is a correlation between solutions to the control of sunlight for thermal reasons and for those of glare – cutting out sunlight from different directions to avoid overheating in summer will reduce glare for the interior – but it should be borne in mind that the reduction of glare may not by itself provide a solution to the provision of thermal comfort.

The natural environment aspects, the unique qualities of daylighting make their introduction into buildings as relevant as when there was no viable alternative in artificial sources:

1. *Change and Variety* – the direction of the light, which provides modelling to the interior, the nature of sun and sky;
2. *Color and View* - the contact with the exterior beyond, such as a view through the window, an experience of the weather and the world outside, the natural colour associated with daylight which imparts reality to the interior;
3. *Modelling and orientation, Sunlight effect* - the mood created by the variation of light, from day to day, and time to time as affected by the weather and seasons, the dynamics of lighting.

The avoidance of glare is a maximum priority for most architectural programmes, particularly those with fixed work positions, and ‘add-ons’ after the building is complete, such as internal shading devices, are not the solution. Much can be done by external shading or high-tech glass; what is important is that glare avoidance is an integral part of design strategy being planned for and executed at the design stage of the building. On certain elevations the window may require protection from solar radiation, either through the selection of the glass used or by external shading, or both. The use of internal shading is less efficient for thermal control, but is more easily managed. When used, external shading becomes a structural element and is both visually and structurally important: visually it has an impact on the external appearance of the building and structurally it must withstand all the external pressures applied to it.

The average Daylight Factor gives a measure of the overall level of daylight in a room. With a 5% average DF the room will have a well daylight appearance, whilst a 2% average DF may require supplementary artificial light in work spaces for much of the time. However a 2% average DF is very adequate in a domestic situation.

A difference in the perception of spaciousness occurs when penetration of the boundaries are windows, doorways, or other openings in the spatial envelope, providing mental engagement for the eye by connecting the space of the observer with outside activities. Ne’eman and Hopkinson (1970) found that the main determinant for people’s preference for window openings was the amount of visual information provided by the outside view. Keighley (1973) stated that the most frequently preferred opening was a central, horizontally shaped window that provides a view to the skyline, and that the preferred window opening is a large horizontal aperture, that occupied 25% to 30% of the wall into which the window was cut.

2. Daylighting systems

Daylighting systems can be classified [2], after their main function as systems with shading and systems without shading.

Two types of daylighting systems with shading are discussed: systems that rely primarily on diffuse skylight and reject direct sunlight, and systems that use primarily direct sunlight, sending it onto the ceiling or to locations above eye height.

Shading systems are designed for solar shading as well as daylighting; they may address other daylighting issues as well, such as protection from glare and redirection of direct or diffuse daylight. The use of conventional solar shading systems, such as pull-down shades, often significantly reduces the admission of daylight to a room. To increase daylight while providing shading, advanced systems have been developed that both protect the area near the window from direct sunlight and send direct and/or diffuse daylight into the interior of the room.

Daylighting systems without shading are designed primarily to redirect daylight to areas away from a window or skylight opening. They may or may not block direct sunlight. These systems can be broken down into four categories:

- Diffuse light-guiding systems redirect daylight from specific areas of the sky vault to the interior of the room. Under overcast sky conditions, the area around the sky zenith is much brighter than the area close to the horizon. For sites with tall external obstructions (typical in dense urban environments), the upper portion of the sky may be the only source of daylight. Light-guiding systems can improve daylight utilization in these situations
- Direct light-guiding systems send direct sunlight to the interior of the room without the secondary effects of glare and overheating
- Light-scattering or diffusing systems are used in skylit or toplit apertures to produce even daylight distribution. If these systems are used in vertical window apertures, serious glare will result
- Light transport systems collect and transport sunlight over long distances to the core of a building via fiber-optics or light pipes.

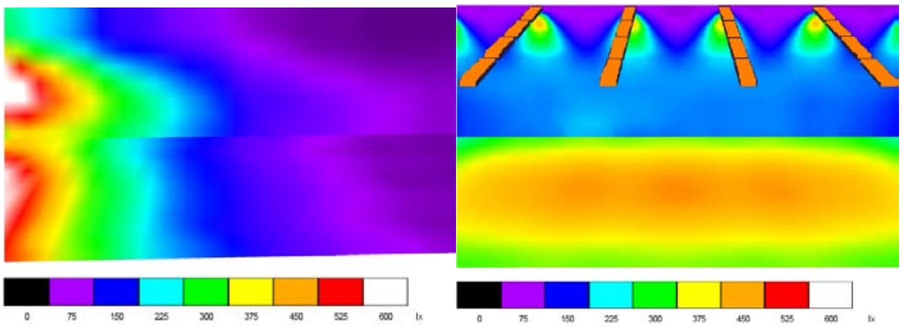
Some systems can fulfil multiple functions and are therefore in more than one category. Light shelves, for instance, redirect both diffuse skylight and beam sunlight [3].

3. Tubular daylight guidance systems (TDGS)

Traditional vertical window can provide adequate daylight within about six meters of the window. Daylight levels decrease asymptotically with distance from the window so that a disproportionate amount of daylight/solar gain must be introduced into the front of the room to achieve small increases in daylight at the back. While this can increase energy savings over a larger room area by offsetting electric lighting energy, the corresponding increase in cooling due to solar heat gain, and/or heating due to structural heat loss, can negate these savings. The use of glazed areas on other parts of the building envelope including atriums, skylights and roof monitors may light some areas remote from windows but these are of limited use in lighting deep core areas [1].

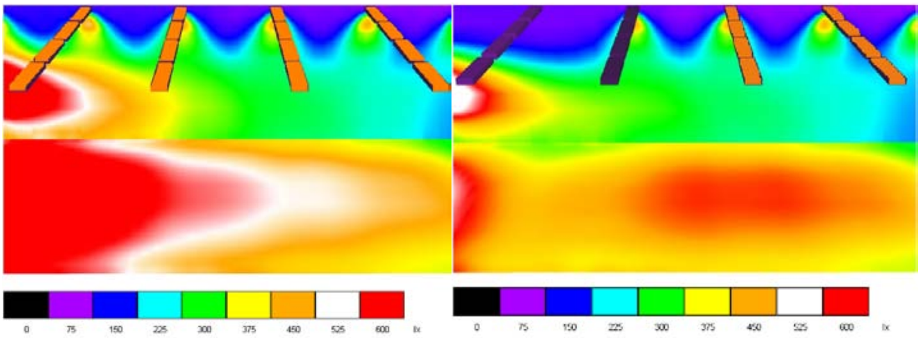
The estimated lighting level was simulated with Dialux 4.6 Software for a room (6*12 m) situated in Bucharest. The room has the windows orientation NE on the 6 m wall. In Figure 3.1 it can be seen the limited amount of daylight inside a 12 m deep room. The same figure illustrates the lighting level when there are used fluorescent 36 W lamps.

Figure 3.2 shows the simulated lighting level under the same conditions, first all the lamps on and second the one close to the window turned off.



Daylight Artificial

Figure 3.1 Lighting levels for a room (l=6 m, L=12 m, windows on the left side NE, simulation for a building situated in Bucharest, summer time)



Daylight + Artificial Daylight + Dimmed Artificial

Figure 3.2 Lighting levels for a room (l=6 m, L=12 m, windows on the left side NE, simulation for a building situated in Bucharest, summer time)

A number of systems exist to redirect daylight into areas of buildings that cannot be lit by conventional glazing. One major generic group is known as 'beam daylighting' - redirects sunlight by adding reflective or refracting elements to conventional windows. The second major group is known as 'tubular daylight guidance systemsTDGS'.

TDGS consist of a light transport section with, at the outer end, some device for collecting natural light and, at the inner end, a means of distribution of light within the interior – Figure 3.3. Collectors may be mechanical devices that actively direct daylight (usually sunlight), or be passive devices that accept sunlight and skylight from part or whole sky hemisphere, and may be located at roof level gathering light from the zenithal sky or on the building façade. Zenithal openings capture light from the brightest sky region but may cause glare or overheating due to direct solar penetration. Orientation is a major determinant of collection efficacy in façade mounted collectors. The transport element is usually a tube lined with highly reflective silvered or prismatic material and may contain lenses or other devices to redirect the light. Light is distributed in an interior by emitters which differ little from conventional luminaires. Light transport is the feature that sets tubular guidance systems apart from other daylight redirection methods. The principal function of transport elements is to deliver light from the collector to the point of exit but some may additionally act as emitters. Recently considerable research effort has been directed at transport systems, a major factor being the availability of new low cost light redirection materials. Usually there are four different transport methods, namely, beam/lens systems, hollow mirrored pipes, hollow prismatic pipes, and solid core systems.

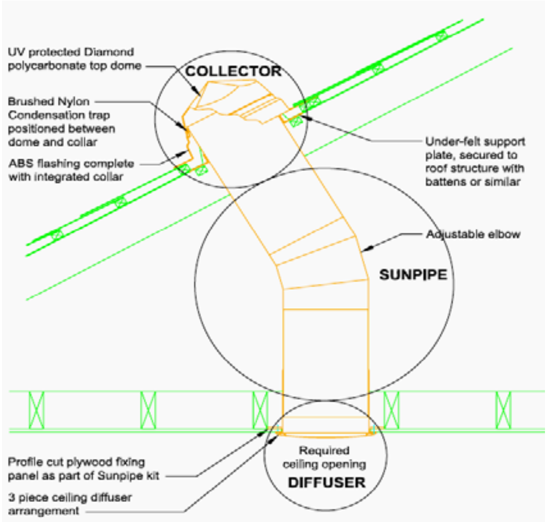


Figure 3.3 Tubular daylight guidance system with passive collector [4]

The light pipe, lined with highly reflective material, is used to guide sunlight and daylight into occupied spaces (Figure 3.3). Highly reflective materials include anodised aluminium and coated plastic film such as Silverlux, which have reflectance greater than 95%. Commercial light pipe are available from a number of manufacturers, in straight and bend sections for on-site assembly and installation. They allow the light pipe to go through complex roof spaces to reach rooms that are not easily accessible to skylights. A light pipe is normally fitted with a clear top dome which removes harmful UV radiation and prevents the ingression of rain water and dust. A diffuser fitted to the bottom of the light pipe ensures that light is distributed around the room it illuminates. Compared to skylight or windows, the light pipe transmits less solar heat on to the illuminated surfaces. This is particularly valuable in summer for preventing inhabitable hot spots in a building. In winter, a light collector (e.g., a sun-scoop) could be mounted above the top opening to allow significantly more sunlight from low angles to be collected [5].

4. Case of study (passive TDGS installed in Cluj-Napoca)

The experimental set up is shown schematically in Figure 4.1.

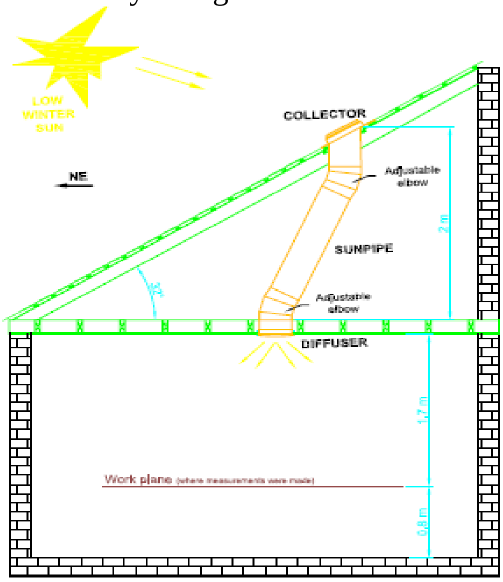


Figure 4.1 TDGS set-up for a pitched slate roof faceing NE

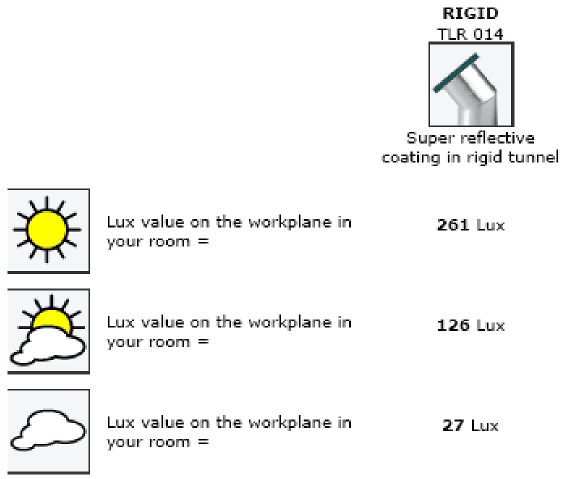
A light pipe produced by the Velux Company was mounted inside a 4.2*3.5 m room on the first floor of the building. The house is part of a duplex situated in Cluj-Napoca. The cylindrical light pipe has a length of 2 m and a diameter of 430 mm. A highly reflective film is laminated, using adhesives, to the interior surface which has a minimum reflectivity of 95%. The top of the pipe was sealed with a clear anti-yellowing acrylic plate. A pearl white diffuser was fitted to the lower opening of the light pipe for even light distribution within the room.

The owners of the house guide themselves in choosing the right device for their application using the technical support of Velux Company. The calculation were made using Velux Lux Software. The results provided by the software are shown in Figure 4.2.

Illuminance measurement was carried out using a standard light meter which had a range of 0.05 - 100,000 lux. The meter was based on a photovoltaic cell which has a spectral response similar to that of a standard human eye thus avoids the need for correction for various types of light sources.

Illuminance of the sun on the open field and that within the working plane inside the room were obtained using two separate photocells. The readings were recorded manually and cares were taken to ensure that there was no passing clouds or other significant changes of lighting condition between reading the two cells. The photocell within the room was normally placed in the centre, at a 0.8 m distance above the floor where the working plane is assumed to be. Measurements were carried out in three different days in the winter time. As shown in Table 4.1, the readings made in the first day - 29.12.08 - are not conclusive because of the ice covering the collector.

The lighting levels inside the room are poor but they match with the predicted results of the Velux Lux Software. The system has three big problems to be solved: the flat collector, the roof peek shadowing the collector and the NE orientation of the roof. The change of the collector with an acrylic dome and the extension of the sun pipe up to a level where the roof peek has no influence will also eliminate the orientation problem of the roof.



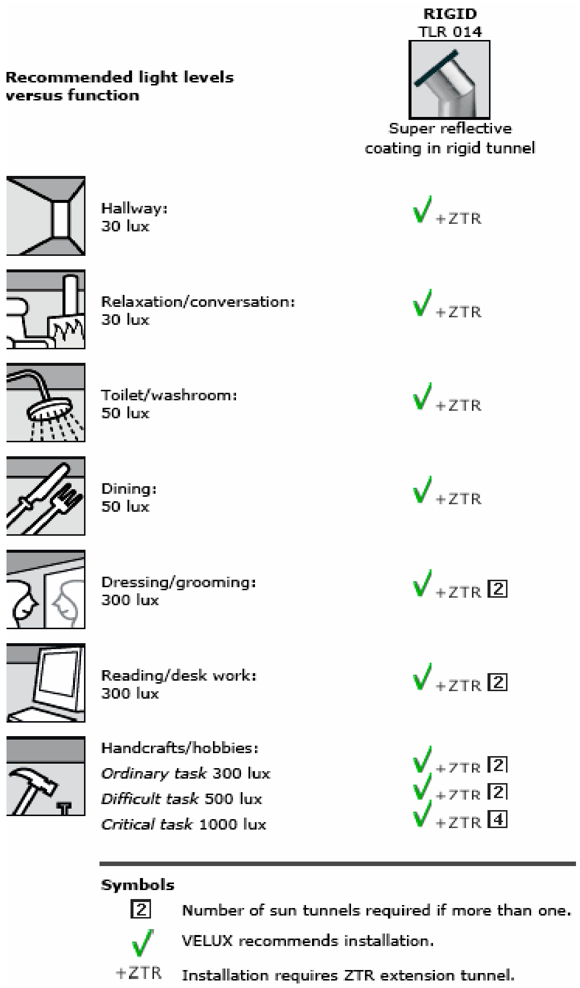
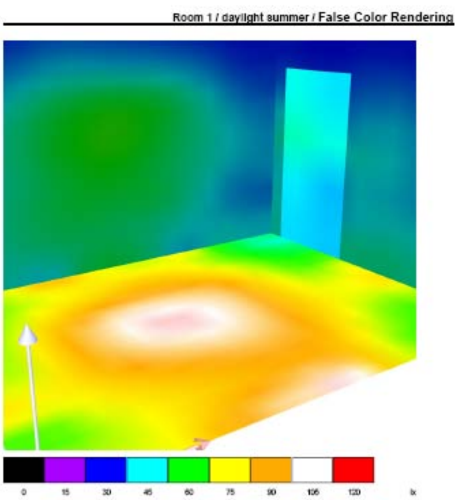


Figure 4.2 Velux Lux Software – results [6]

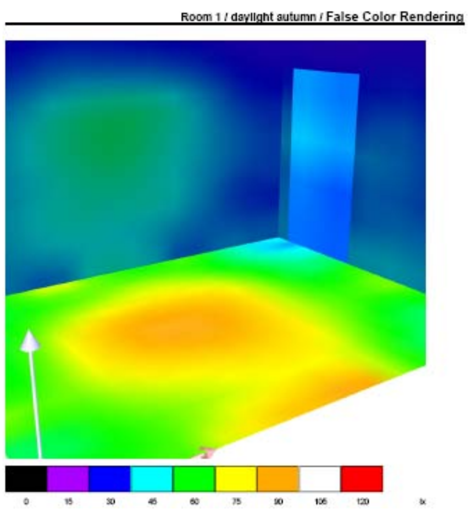
Some simulations were made for the same room using the Dialux Software. There were taken into consideration the four seasons, the 12:00 hour of 15 of January, April, July and October, plus the exact latitude and longitude of the building. The TDGS was assimilated with a roof light but the direct sun light was not taken into consideration for the calculation. Also the roof peek shadow was not considered for the simulation. Opposite to the measurements results, F 4.3 shows the lighting levels on the room floor.

Table 4.1 Illuminance measurments

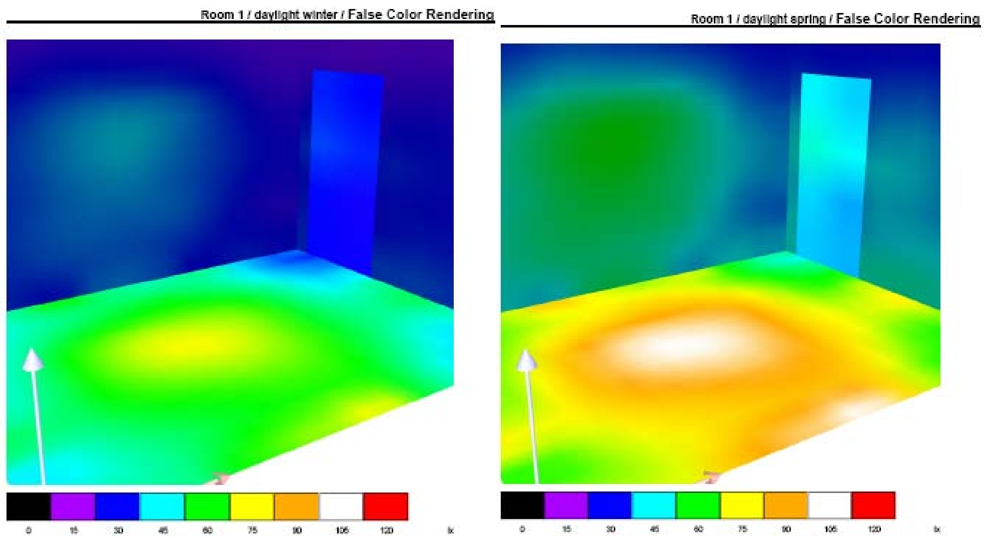
Date	Hour	Work plane illuminance	External illuminance	Internal / External Ratio	Comments	Average work plane illuminance
		lx	lx	%		lx
29.12.08	8:35	7,5	1.200	0,63	 The collector was covered in ice	**19,18**
	9:00	10,0	2.300	0,43		
	9:22	14,0	2.900	0,48		
	9:46	19,0	4.500	0,42		
	10:00	20,0	5.000	0,40		
	10:17	22,5	5.500	0,41		
	10:30	22,5	5.500	0,41		
	11:00	27,0	8.000	0,34		
	11:30	30,0	8.300	0,36		
	12:00	25,0	7.500	0,33		
	12:40	23,0	6.500	0,35		
	13:50	21,0	5.150	0,41		
	14:50	20,0	5.000	0,40		
	15:50	7,0	1.150	0,61		
04.02.09	13:13	135,0	24.000	0,56		**64,75**
	13:33	85,0	10.000	0,85		
	13:50	60,0	4.400	1,36		
	14:15	34,0	3.200	1,06		
	14:30	40,0	3.600	1,11		
	15:00	69,0	5.000	1,38		
	15:20	55,0	4.500	1,22		
	15:40	40,0	3.500	1,14		
06.02.09	10:59	100,0	11.400	0,88		**112,25**
	11:15	88,0	7.500	1,17		
	11:20	92,0	19.000	0,48		
	11:39	98,0	20.000	0,49		
	12:02	120,0	26.000	0,46		
	12:10	130,0	28.000	0,46		
	12:38	140,0	18.000	0,78		
	13:23	130,0	12.000	1,08		



Summer



Autumn



Winter Spring

Figure 4.3 Dialux 4.6 simulations – results

5. Conclusions

Daylighting systems require a specific conception, very close related to the geographic context where they are built, to environment (natural and artificial obstructions), to imposed levels of visual comfort and to climate.

The development of new materials with better performance in light reflection and transmission has lead to various solutions of energy efficient lighting systems able to grow potential for future applications.

Any technical and economical analysis of these systems must take into account both energy efficiency, and visual comfort conditions for the lighted spaces. For example, these solutions present outstanding possibilities to improve visual comfort in underground spaces, which are energy efficient due to low thermal losses.

Perspectives offered by these solutions of integrated lighting systems lead to a higher visual comfort and to new possibilities of space utilization.

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Paper presented at the 5th International Conference ILUMINAT 2009, 20 February 2009, Cluj-Napoca, Romania.
The author of this paper, Călin CIUGUDEANU, was granted with the Award of the Ph.D. Students Best Paper

ENERGY SAVING LIGHTING CONTROL SYSTEMS FOR OPEN-PLAN OFFICES: A FIELD STUDY

Anca D. GALAŞIU[1], Guy R. NEWSHAM[1], Cristian ŞUVĂGĂU[2], Daniel M. SANDER[3]
1) National Research Council Canada, Institute for Research in Construction, Indoor Environment Program; 2) BC Hydro, Techology Solutions Power Smart; 3) National Research Council Canada (retired)

Abstract *We conducted a field study in a deep-plan office building equipped with suspended direct-indirect luminaires located centrally in cubicle-workstations. In order to reduce lighting energy use, the luminaires employed integral occupancy sensors and light sensors (daylight harvesting), as well as individual dimming control accessed through occupants' computer screens. Data were collected from 86 workstations over a year to examine the energy savings and power reduction attributable to the controls, and how the controls were used. An awareness campaign that used e-mail reminders to encourage the occupants to use the individual control feature of the lighting system was also conducted. Results indicate that the lighting system generated substantial energy savings and peak power reductions compared to a conventional fluorescent lighting system installed on a neighbouring floor. The installed lighting power was 40% lower than that of the conventional system. The three controls combined saved 42 to 47% in lighting energy use compared to the same lights used at full power during work-hours; this translated into overall savings of 67 to 69% compared to the conventional lighting system. If the three lighting controls systems had been installed separately, occupancy sensors would have saved, on average, 35% if used alone, light sensors (daylight harvesting) 20%, and individual dimming 11%. The light sensor savings were, as expected, higher in perimeter workstations, and would have matched the performance of the occupancy sensors with some modifications to the control parameters. The average daily peak power demand for lighting was also reduced by a similar amount, which resulted in an average effective lighting power density of only 3 W/m^2. Although not detailed in this paper, surveys indicated that the studied lighting system was also associated with higher occupant satisfaction. This was likely due to the individual dimming control, although use of this control beyond an initial preferred setting was rare.*

Keywords*: lighting, daylighting, lighting controls, occupancy sensors, individual controls, lighting systems, daylight-linked dimming, energy savings, open-plan offices*

Ingineria Iluminatului 2009; **11**, 2 : 15 - 38

1. Introduction

As part of the effort towards sustainability, buildings need to use less energy. Canadian office buildings were reported in 2004 to have used 33% of the total energy used by the commercial/institutional sector, with lighting accounting for 10% of the total building energy use, and 24% of the electricity use (NRCan 2006). Several research studies have generated promising results suggesting that electrical energy use can be substantially reduced by using lighting control systems such as daylight-linked dimming and occupancy sensors (Maniccia and others 1999; Jennings and others 2000; Lee and Selkowitz 2006). Individual (personal) dimming controls have also been shown to reduce energy use, while increasing occupant satisfaction (Boyce and others 2003; Newsham and others 2004).

Despite the fact that various energy saving technologies have been available for some time, their implementation continues to be very slow. This is not surprising, however, given the scarcity of long-term performance assessments demonstrating that these systems do work as asserted and justify their higher initial cost. Many earlier investigations either took place in laboratory settings, or reported failures in attaining the projected energy savings, revealing significant problems with commissioning and user acceptability (Bordass and others 1994; Love 1995; Slater 1995, 1996; Heschong Mahone Group 2006). Even fewer studies have surveyed concurrently the opinions and preferences of the users of these systems. A review of the scientific literature to date showed that there is almost no information available on the long-lasting success of energy-saving lighting control technologies when used in combination in real buildings. This study was designed to partially remedy this gap and to generate information that could improve the uptake of such lighting controls in buildings.

The study took place in an open-plan office building featuring a lighting control system equipped with occupancy sensors, daylight-linked dimming, and individual dimming control accessed through occupants' computer screens. It included the monitoring of the energy use of the lighting system over the course of a year, along with an evaluation of the occupants' satisfaction with the lighting system and their work environment, and the occupants' use of the Venetian blinds. In this paper we focus on the energy performance of the lighting control system; other aspects of the study will be reported in future publications. Specifically, we present here:

- The overall energy savings and power demand reductions attributable to the lighting control system compared to (1) the energy used at full power during work-hours by the installed system, and (2) a static, ceiling-recessed, conventional fluorescent lighting system on a neighbouring floor.
- The separate energy-saving contributions from individual control, occupancy sensors and daylight photosensors, a key factor toward optimizing the performance of automatic lighting control systems.

- The effect on the energy use and power demand of an intervention to the workplace expected to increase energy savings. The intervention consisted of an awareness campaign, which used e-mail reminders to encourage the occupants to use the individual control feature.
- The energy-saving potential of four other design/operation options that, in theory, could have further reduced the energy use of the lighting system.

2. Literature review

A number of prior research studies relevant to this study are summarized below.

Jennings and others (2000) found that in private offices occupancy sensors that turned the lights off after a 15-20 minute period of no-occupancy saved between 20-26% in lighting energy compared to the manual operation of a wall switch alone. Daylight-linked dimming provided additional savings of about 20%. In the offices where occupancy was low, energy savings resulted mostly from the occupancy sensors, while in the offices with high occupancy, savings were mostly attributable to light sensor dimming. In the offices where manual wall dimmers were available, savings were in the range of 9% by occupant dimming alone, while savings in areas with occupant bi-level switching of a 3-lamp fixture were 23%. The authors noted that “by the time the (dimming) system had been in place for over a year there was little significant (manual) dimming activity taking place”. When the lights were on, they were usually used at more than 90% of full power. The authors speculated that the occupants may have used the manual dimmers more actively had they been placed closer to their working area (desktop mounted or hand-held remotes). Comparing the occupants’ switching behaviour in the offices that had occupancy sensors to the ones that did not have them, the authors did not find any evidence to suggest that people without occupancy sensors would be more likely to manually switch the lights off when leaving the office for long periods of time than the people having them.

In contrast, based on a study conducted in 63 private offices over 11 months, Pigg and others (1996) concluded that people are likely to change their behaviour in the presence of controls. In offices equipped with occupancy sensors, the occupants were “half as likely to turn out the lights” when leaving the space compared to people without occupancy sensors. The authors noted that if the occupants with occupancy sensors had switched the lights manually, the savings from that group would have increased by 30%. The additional energy used was due to the lights remaining on during the time-delay of the occupancy sensors. Similarly to people in Jennings and others (1999), people in both groups selected full lighting output from the luminaires when using wall-mounted dual-level switches: 95% of the time in the offices with occupancy sensors, and 89% of the time in the control group. The authors speculated that people who rely on controls to operate the lights are less likely to choose “a switch setting other than full illumination.” While the occupants did not adjust their lights very often, they appreciated the ability to do so.

Boyce and others (2000) speculated that given control over lighting, people would "initially explore the range of illuminances available and then gradually home-in on the illuminances they like." This suggests a decrease in the frequency of use of controls over time. However, the authors did not perceive this as an argument against the provision of such control. The participants in Boyce's experiment viewed the ability to select lighting levels as highly desirable, and the light levels they selected were linked to the type of work that they did.

In daylit private offices, based on responses to questionnaires, Maniccia and others (1999) found that occupants did not consciously use their manual light dimmers to save energy but rather to accommodate the tasks they performed. Nevertheless, data showed that the selected light levels did not vary with the type of task. Offices were occupied an average of 4½ hours a day and 74% of the 58 occupants observed over a 7-week period used their wall-mounted or portable desk-dimmers to adjust their lights. Over half of the time the lights were either dimmed or turned off. Energy savings from the manual controls were 15% in addition to savings from occupancy-based controls, which provided 43% savings on their own. Upon re-entering the office after the occupancy sensors had extinguished the lights, the lights remained off unless the occupant used the dimmers to restore them. The occupants appreciated having the dimmers located on their desks, and removing the desk-dimmers (so that dimming was possible via a wall switch only) resulted in fewer dimming adjustments.

Several investigations into various open-plan office buildings in the UK showed that occupants generally prefer to have the capability to choose their own lighting environment rather than having to accept lighting levels chosen for them (Slater and Carter 1998; Slater and others 1998; Carter and others 1999; Moore and others 2001, 2002). Questionnaires from 410 occupants collected over a 3-year period showed that the occupants viewed the installations that they could control more positively, even when the measured lighting conditions did not meet the currently recommended lighting levels for offices. The authors noted that individuals purposely used the controls to set their preferred lighting levels and not only to counteract discomfort. They reported that "by far the most frequent response was that people wanted control over an individual luminaire" (Moore and others 2002). In the winter, 20% of the users chose illuminance levels below 100 lux, while over 50% worked at levels below 300 lux, and less than 25% worked under the recommended 300-500 lux range. All lighting installations were used at less than full power, the average power demand varying between 50 to 60% all year round. Building depth, percentage of glazed area, or degree of obstructions had no effect on these outputs. Conflicts were reported in areas where groups of luminaires were linked together and controlled by more than one user. While the authors found that individuals generally worked in a very wide range of illuminances, they also noted "a strong correlation between luminaire output and distance of the workstation from the window" (Carter and others 1999). This suggests that people actively changed the electric light levels in response to the available daylight.

After surveying several open-plan office buildings in the UK incorporating various types of lighting controls, Bordass and others (1994) also reported that unfamiliarity with controls or the bad locations of controls discouraged their use. These authors suggested that the best location for switches while working is at the workstation. The authors also reported high rates of dissatisfaction with photocontrolled lighting due to the lights going on/off inappropriately; distracting transitions; incorrect installation and calibration; and lack of possibility to override them. Occupancy sensing was also not always perceived positively due to the lights going off inappropriately. The very few successful installations they found, from both occupant satisfaction and energy efficiency points-of-view, were: installed according to workstation layout and daylight availability; had local controls with clear user interfaces permitting easy-tuning to individual requirements; had easy access to blinds; well-informed occupants; and good building management. Similar observations were made by Slater (1995, 1996), Escuyer and Fontoynont (2001), Roche and others (2001), and Wyon (1999).

Based on 26 case studies that investigated the effectiveness of occupancy sensors to generate energy savings in various space types, Figueiro (2004) proposed estimates for expected energy savings from occupancy sensors in private and shared spaces, with scheduled versus sporadic use. In private offices with sporadic use, occupancy sensors accounted for an average of about 25% energy savings during 7.5 to 10 hours of use, while in shared spaces with sporadic use, including open-plan offices, the average savings were around 40%. In shared spaces with scheduled use, such as classrooms, the average savings were around 30%. The larger energy savings related to occupancy sensors installed in shared spaces was attributed to the fact that in such spaces the occupants generally do not feel as responsible for manually switching off the lights when leaving a space as they would when leaving a private office.

In a full-scale open-plan test installation with 1.2 m high workstation partitions, Lee and Selkowitz (2006) tested two types of daylight-linked lighting system (open-loop dimming system with proportional control, and a DALI dimming system) and found that the lighting energy savings were still substantial at a depth of 7 meters from a window wall equipped with automated roller shades. In a side-lit area with an open-loop dimming system, from mid-February to mid-September, the average savings for a 7-meter depth zone were 20-23%. At the same distance from the window, in a bilateral daylit zone featuring the DALI dimming system, the average savings were 52-59%. In the DALI area, the lights were turned off when there was sufficient daylight (0 light = 4% of full power draw), whereas in the area featuring the open-loop dimming system, the lights were dimmed only down to a minimum power (5-10% light = 35% of full power consumption). The authors noted that “without active shade management” the energy savings would have been significantly lower "due to non-optimal control by the occupants".

3. Site description

The study was conducted on floors 8 to 11 of a 12-storey rectangular, curtain-wall, green-tinted glazed structure (Fig. 1) located in Burnaby, British Columbia, Canada, (latitude 49°11', longitude 123°10'). The study floors consisted mostly of open-plan areas (75% of total floor area) furnished with cubicle-type workstations and no private offices. A few enclosed areas were located at the core of the building providing shared spaces for meeting rooms, break rooms, and storage. All perimeter workstations had two or three window panes equipped with manually operated Venetian blinds. Each floor had an approximate area of 835 m^2. The height of the partitions between the workstations varied from 0.84 m next to the windows, to 1.25 m between two adjacent workstations, and 1.42 m next to the aisles. There were few external obstructions to hamper daylight admittance into the building.

Figure 1 North-east view of the test-site.

The majority of workstations on the study floors had commercial direct-indirect luminaires suspended at about 0.3 meters below the ceiling and located centrally in each workstation (Fig. 2). When fully on, the system provided an average illuminance of 450 lux in the centre of the workstation at 0.85 m above the floor (desktop height).

Figure 2 Typical installation of the lighting fixtures.

Each luminaire (Fig. 3) consisted of 3x32-W lamps (3500 K) connected by a network to a central control computer and to each occupant's desktop computer. The fixture also included an occupancy sensor and a daylight photosensor. The lamp in the center of the luminaire was equipped with a static electronic ballast and directed the light mainly upward, providing constant general lighting around the open-plan space. During the study, these lamps were controlled centrally based on a daily schedule that kept them continuously on at full power from 7:30 AM to 5 PM on workdays. Outside of these hours, the uplights were turned on by an integrated occupancy sensor when sensing occupancy in the vicinity.

The two lamps at the sides directed the light mainly downward. The downlights were controlled during the study based on the following three control options:

- An integrated occupancy sensor (OS). It consisted of an infrared motion sensor mounted directly on the light fixture. On detecting vacancy, the sensor prompted the downlights to gradually dim down to zero and switch-off. When presence was detected, the downlights were automatically restored to the previously set lighting level.
- An integrated light sensor (LS), used to monitor the surrounding light levels and dim the downlights when sufficient light (from either daylight or neighbouring electric light) was present to maintain the occupant preset light level. The light sensor consisted of a photocell mounted directly on the light fixture.
- Individual control (IC), consisting of an on-screen slider located on the occupants' desktop computers that allowed both on/off switching or dimming of the downlights to a preferred level.

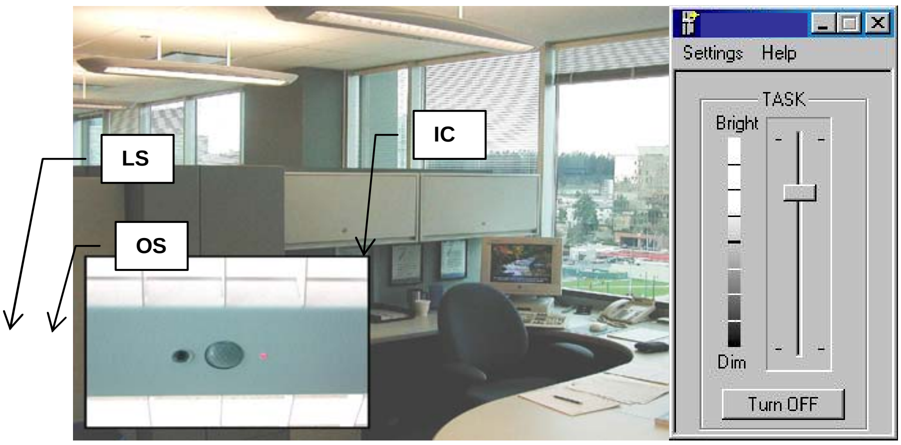

Figure 3 Illustration of the three control options of the luminaire downlights

During the study, the field installation comprised a total of 195 light fixtures distributed over floors 8, 9, 10 and half of floor 11. At installation (4 years prior to this study), these fixtures replaced a total of 530 2'x4' (60x120 cm) conventional ceiling-recessed fluorescent louvered luminaires with 2x32-W T8 lamps (3500 K) and electronic static ballasts, which reduced the lighting power density by almost half (5.6 W/m^2 versus 10 W/m^2). This conventional lighting system remained in the other half of floor 11, and provided a comparison group in the occupant satisfaction survey conducted as part of the larger project.

4. Method

4.1 Characteristics of lighting system operation

Data related to the lighting fixtures was continuously collected over a 12-month period in three phases:

- Phase 1 was conducted from January 18 to March 11, 2005 (39 workdays) with the light sensor disabled. During this time the downlights were controlled only by the occupancy sensors and the on-screen individual controls. The occupancy sensors were set to operate with a time-delay of 8 minutes. This time-delay was followed by a period of 7 minutes of continuous dimming before the downlights turned off.
- Phase 2 was conducted between March 12 and October 2, 2005 (140 workdays) with all the controls enabled. The occupancy sensors were set to operate with a time-delay of 12 minutes. This time-delay was followed by a period of 3 minutes of continuous dimming before the downlights turned off, which resulted in a total time between the last detected motion and the downlights off condition of 15 minutes (equivalent to the previous period).
- Phase 3 (Awareness Campaign) was conducted from October 3 to December 31, 2005 (61 workdays) similar to Phase 2 with the exception that monthly e-mail reminders were sent to the employees to: remind them about the lighting control system; provide them with information on how to use it; and encourage them to save energy by using the on-screen individual lighting controls.

All lighting fixtures were preset at installation to restrict downlight dimming to 50% light output when controlled by the light sensor. This was done to prevent large variations in light levels, which the design team believed might inconvenience the occupants. The occupants could still dim the downlights using the on-screen control to any levels below this limit, if desired. When turned on, but dimmed to minimum output, the power demand of the downlights was 19 W (or 51 W/fixture, including the 32 W uplight), whereas dimmed at 50% output, the power demand of the downlights was about 41 W (or 73 W/fixture).

4.2 Monitoring of lighting system energy use and power demand

Each individual light fixture was monitored using a modified version of the communication software provided by the manufacturer as part of the standard installation of the lighting system. The software was adapted to automatically log the energy use of each luminaire every 15 minutes, and record the occupant use of the on-screen control slider, and the status of the occupancy and daylight sensors. The field-installation reported the energy use of each light fixture with all available controls in operation simultaneously. However, since we also wanted to derive the separate saving contribution of each control, we developed a mathematical model to calculate the energy use and power demand of each light fixture if only one control, or two controls combined, had been in operation. The mathematical model used correlations between the dimming level, electric power demand, and light sensor, occupancy sensor and on-screen individual control setpoints, determined based on the field-collected data and measurements from a similar system installed in a laboratory setting.

To calculate the savings associated with the controls, we considered the following three basic cases, which assumed full lighting energy use during work-hours:

- energy use and power demand in the absence of controls during the basic daily work-schedule of the lighting system (7:30 AM to 5 PM).
- energy use and power demand in the absence of controls during the total work-hours (basic work-schedule, 7:30 AM to 5 PM, plus the additional time that the lights were reported to have been on outside the scheduled hours).
- energy use and power demand of a conventional lighting system consisting of 2'x4' (60x120 cm) parabolic louvered luminaires with 2x32-W T8 fluorescent lamps, during the total work-hours.

For each of the three phases of the study, we calculated the percentage in energy savings and the power demand reductions with the downlights controlled by:

- occupancy sensors only (os); In this case it was considered that no individual control or light sensor control were available, therefore, the downlights would have been used continuously at full power when the occupants were present in their workstations (actual occupancy), and off at other times.
- individual controls only (ic); In this case it was considered that no occupancy or light sensor control were available, therefore, the downlights would have been used at the occupant-selected level during the total work-hours.
- light sensor controls only (ls); In this case it was considered that no occupancy or individual control were available, therefore, the downlights would have been used continuously at the light sensor selected dimming level during the total work-hours.
- occupancy sensors and individual controls combined (os+ic); In this case the downlights would have been used at the dimming level set by the occupants during the workstation actual occupancy, and off at other times.
- occupancy sensors and light sensor controls combined (os+ls); In this case the downlights would have been used at the dimming level set by the light sensors during the workstation actual occupancy, and off at other times.
- individual controls and light sensor controls combined (ic+ls); In this case the downlights would have been used at a dimming level selected to be the minimum between the dimming level dictated by the light sensor setting and the dimming

level dictated by the individual control setting during the total work-hours.

- all available controls combined; (os+ic) for Phase 1; (os+ic+ls) for Phases 2 and 3; In this case the downlights would have been used at a dimming level selected to be the minimum between the dimming level dictated by the light sensor setting and the dimming level dictated by the individual control setting during the workstation actual occupancy, and off at other times. These values, calculated with the same mathematical model used for the one-control and two-control scenarios described above, were subsequently compared to the real energy use reported by the lighting system monitoring software, being indicative of the accuracy of our theoretical model.

All calculations included the energy used by the uplights, which were continuously on at full power during scheduled hours, and on outside these hours when occupancy was detected in the workstations.

In order to identify the effect of the downlight dimming restriction on the energy use, we also calculated the energy savings if the downlights had been allowed to drop to zero on light sensor control. Furthermore, we also calculated the energy savings associated with three other design/operation options that could have, theoretically, further reduced the energy use, as follows:

Option 1 = lighting system equipped with 32-W static uplights and 2x32-W dimmable downlights (as installed), but with the downlights allowed to dim to zero on light sensor control;
Option 2 = lighting system with 25-W static uplights and 2x32-W dimmable downlights allowed to dim to zero on light sensor control;
Option 3 = system with 3x32-W dimmable uplights and downlights, both restricted at 50% output on light sensor control;
Option 4 = system with 3x32-W dimmable uplights and downlights, both allowed to dim to zero on light sensor control.

The above calculations apply only to the data collected during Phases 2 and 3 when the lighting system operated with all three controls enabled.

4.3 Data access and sample size

Because the study included the examination of the lighting control usage data at the individual level, formal consent to analyse the lighting system data was sought from each occupant, in accordance with the requirements of our Research Ethics Board (similar requirements were met for the survey aspect of the larger study). Only the records logged in the workstations where the occupants gave specific permission to release their data for analysis were included. This reduced the sample size from 195 to 86 light fixtures, of which 57 were located in workstations located at the perimeter of the building with direct access to windows; 18 were located in 2nd row workstations adjacent to the perimeter workstations at distances between 2.5 and 4.5 meters from the windows; and 11 were located at the core of the building at distances greater than 5.0 meters from the closest window. The sample size was not big enough to permit analysis by façade orientation.

5. Results

5.1 Lighting system used at full power during work-hours

Data collected throughout the year showed that during all three phases of the study, the actual average daily time-of-use of the lighting system was higher than the 9.5 hours used by the lighting system schedule (7:30 AM to 5 PM), as shown in Fig. 4. Whereas, due to the occupancy sensors, the average daily on-time of the downlights was between 4-6 hours/day, the uplights were used at full power for an average of 10-11 hours/day.

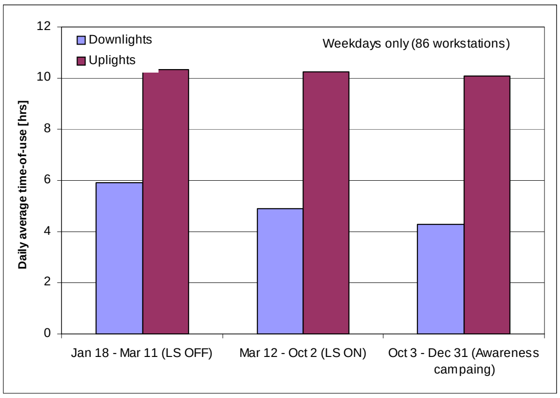

Figure 4 Average daily time-of-use of the lighting system during all three phases of the study.

The average daily energy that would have been used by the downlights if maintained at full power during the actual work-hours was 0.69 kWh/workstation/day for Phase1; 0.72 kWh/workstation/day for Phase 2; and 0.74 kWh/workstation/day for Phase 3. These values are about 10-17% greater than the energy used by the downlights at full power during scheduled hours (0.65 kWh/workstation/day from 7:30 AM to 5 PM). Therefore, we calculated the percentage in energy savings for the various control scenarios mentioned above relative to the energy used by the fixtures at full power during the total daily work-hours, which we considered to be a more realistic comparison baseline than the 9.5 hours used by the lighting system's daily schedule. The average daily energy used by the uplights was about 0.33 kWh/workstation/day.

5.2 Performance of the lighting system as installed

Table 1 presents a summary of the light fixture daily average percentage energy savings and power demand reductions associated with all the control scenarios, compared to full light output from the studied system. Additionally, the table also includes the theoretical energy savings associated with the other four operation/design options mentioned previously.

5.2.1 Energy use

Figure 5 shows the daily average energy used per light fixture during Phase 2 for the various control scenarios. Also shown in Fig. 5 is the calculated energy use of the conventional lighting system (providing a similar target desktop illuminance) at 1.83 kWh/workstation/day. Due to its reduced lighting power density, the installed system would have saved 42% in electric energy if used at full power during work-hours compared to the conventional system.

Table 1 Summary of light fixture daily average energy savings and power demand reductions for various control scenarios compared to full light output from the studied system

	As Installed			**Option 1**		**Option 2**		**Option 3**		**Option 4**	
	Phase 1	**Phase 2**	**Phase 3**	**Phase 2**	**Phase 3**	**Phase 2**	**Phase 3**	**Phase 2**	**Phase 3**	**Phase 2**	**Phase 3**
	Jan18-Mar11	**Mar12-Oct2**	**Oct3-Dec 31**	**Mar12-Oct2**	**Oct3-Dec 31**	**Mar12-Oct2**	**Oct3-Dec 31**	**Mar12-Oct2**	**Oct3-Dec 31**	**Mar12-Oct2**	**Oct3-Dec 31**
Energy Savings	%	%	%	%	%	%	%	%	%	%	%
occupancy sensors (os)	29	35	38	35	38	38	40	52	54	52	54
individual controls (ic)	20	11	5	11	5	11	5	15	7	15	7
light sensors (ls)	-	20	11	32	16	34	18	29	16	47	24
occupancy sensors + individual controls	40	40	39	40	39	43	42	59	56	59	56
occupancy sensors + light sensors	-	45	44	51	46	55	49	66	62	75	66
individual controls + light sensors	-	24	14	34	19	37	21	35	20	51	27
all available controls (estimated)	40	47	44	52	47	56	50	69	64	76	67
all available controls (real)	39	47	42	-	-	-	-	-	-	-	-
Power Demand Reductions	%	%	%	%	%	%	%	%	%	%	%
occupancy sensors (os)	31	36	38	36	38	39	41	54	57	54	57
individual controls (ic)	21	12	5	12	5	13	5	17	7	17	7
light sensors (ls)	-	23	15	39	24	42	25	34	23	59	35
occupancy sensors + individual controls	41	41	40	41	40	45	43	62	59	62	59
occupancy sensors + light sensors	-	47	46	55	50	59	54	70	68	82	74
individual controls + light sensors	-	26	18	41	26	44	28	39	26	61	38
all available controls (estimated)	41	48	46	55	50	59	54	72	69	82	75
all available controls (real)	40	49	43	-	-	-	-	-	-	-	-

Option 1 = Currently installed system if downlights were allowed to dim to zero on LS (maximum as installed saving potential)
Option 2 = System with static 25 Watt uplights and downlights allowed maximum dimming on LS
Option 3 = System with dimmable uplights and downlights restricted at 50% output
Option 4 = System with dimmable uplights and downlights allowed maximum dimming on LS

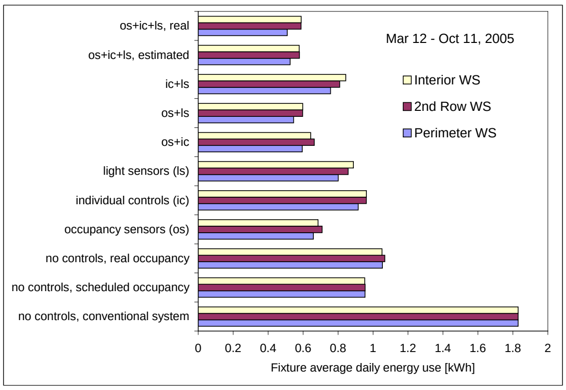

Figure 5 Light fixture daily average energy use for various control scenarios from March 12 to October 2, 2005; the energy use of a conventional lighting system is shown for comparison (data shown by light fixture proximity to windows).

<u>Three-controls scenario</u>

As shown in Fig. 6 (for Phase 2) and Table 1 (for all three phases), the three controls combined (os+ic+ls, real) saved 42-47% compared to the energy used by the same light fixtures at full power. This translated into energy savings of 67-69% compared to the static conventional system (Fig. 7)

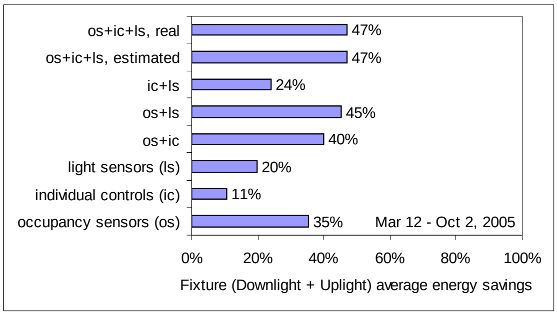

Figure 6 Light fixture average energy savings for various control scenarios from March 12 to October 2, 2005 (Phase 2) compared to full lighting use of the installed system during total work-hours (data shown averaged across all locations; downlight restricted to 50% output on light sensor).

The energy use reported by the system was also remarkably close to the estimated energy use (os+is+ls, estimated), obtained using the theoretical model we used to separate the saving contributions from each control feature if used individually, which provides confidence in the accuracy of the model (Fig.6).

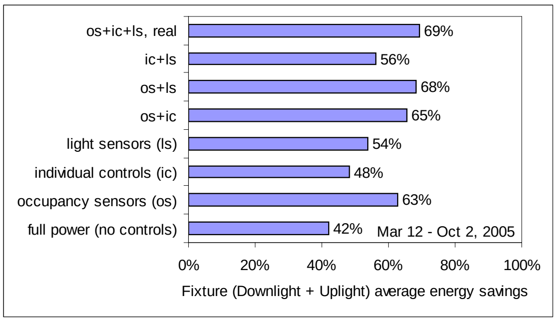

Figure 7 Light fixture average energy savings for various control scenarios from March 12 to October 2, 2005 (Phase 2) compared to the energy use of a conventional static lighting system during total work-hours (downlight restricted to 50% output on light sensor).

<u>Occupancy sensor control scenario</u>

Calculations of the energy use of the lighting system had it been controlled by occupancy sensors only, revealed that the occupancy sensors were the single control option with the highest potential for energy savings. As shown in Table 1, the fixture average daily savings across all three phases of the study were between 29-38% compared to lights fully on during work-hours. These values are slightly higher than those reported for private offices by Jennings and others (2000) and Figueiro (2004), but close to Maniccia and others (1999). A small difference of 4-8% in occupancy sensor savings was observed in our study based on workstation proximity to windows (as shown in Fig. 8 for Phase 2), which was most likely linked to the occupants' type of work rather than to their window/daylight exposure.

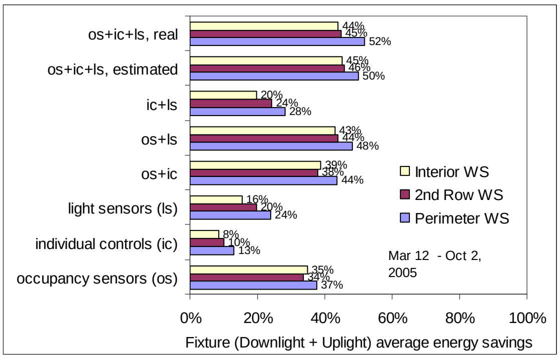

Figure 8 Light fixture average energy savings for various control scenarios from March 12 to October 2, 2005 (Phase 2) compared to full lighting use of the installed system during total work-hours (data shown by light fixture proximity to windows; downlight restricted to 50% output on light sensor).

Light sensor control scenario

Had they been used as the only control option of the lighting system, the light sensors showed an overall potential for energy savings in the range of 10 to 20% compared to the energy use at full power (Table 1). As shown in Fig. 8 for Phase 2, the savings were, as expected, higher in the perimeter workstations (24%) versus the interior workstations (16%). Across both Phases 2 and 3, the light sensor saved between 17-24% in the perimeter workstations; 9-20% in the 2nd row workstations, and 9-16% in the interior workstations. These findings are consistent with Jennings and others (2000) and Lee and Selkowitz (2006). However, in Lee and Selkowitz's study the windows were equipped with automated roller shades, whereas in the present study the windows were covered by manual Venetian blinds. In addition, the height of the partitions between the workstations was 1.2 meters in Lee and Selkowitz compared with varying partition heights of 0.84, 1.25 and 1.42 meters in this study.

Field measurements collected at 10-minute intervals from 6 AM to 6 PM during all weekends of the study, in the absence of electric lighting, indicated that the average daylight illuminance on the top of the partitions separating the workstations was between 200 to 400 lux at distances between 2.5 and 4 meters from the nearest window, and about 100 to 150 lux beyond 5 meters from the nearest window.

Individual control scenario

As shown in Table 1, if used as the only control option, the on-screen individual controls showed the lowest potential for energy savings, ranging from 5 to 11% during Phases 2 and 3, when the light sensor was enabled, to 20% during Phase 1, when the light sensor control was disabled. These values are generally consistent with Jennings and others (2000), Maniccia and others (1999), and Veitch and Newsham (2000).

Table 2 presents the number of workstations with dimming and on/off occupant-requested adjustments for each phase of the study. During Phase 1 (39 workdays), user light level adjustments occurred in 81 out of the 86 workstations considered. However, most of these adjustments occurred at the beginning of Phase 1, in the two days following an unannounced lighting system reset that deactivated the light sensor at the start of the project. During these two days only, there were a total of 55 on/off and 71 dimming user-requests. Throughout the rest of Phase 1, however, the occupants used the on-screen individual controls only occasionally, and the number of workstations where user adjustments occurred (*active workstations*) was similar to that shown for Phases 2 and 3. During Phase 2 (140 workdays), on-off user-requested adjustments were observed in only 40% of the 86 workstations considered, and user-requested dimming occurred in 60% of these workstations. Similarly, throughout Phase 3 (61 workdays), on-off user-requested adjustments were observed in 25% of the workstations, while user-requested dimming occurred in 50% of the workstations.

Table 2 Frequency-of-use of the on-screen individual controls (dimming and on/off occupant-requested adjustments)

	Phase 1	Phase 2	Phase 3
Workdays in period	39	140	61
No.of workstations with manual on/off adjustments (out of 86)	81 (37)*	34	21
No.of workstations with manual dimming adjustments (out of 86)	82 (50)*	52	44
Total number of manual on/off adjustments for all workstations and days	145 (68)*	86	109 (52)**
Total number of manual dimming adjustments for all workstations and days	205 (108)*	138	152 (102)**
Average manual control adjustments/workstation/day (across 86 workstations)	0.10 (0.05)*	0.02	0.05 (0.03)**

*excluding the first week after the initial lighting system reset (Jan 18-25, 2005)
**excluding one outlier user

Even among the active users of the on-screen controls, half used them only once or twice during each phase of the study, the average number of user-requested light level adjustments per active workstation being 1.8 on/off and 2.5 dimming adjustments for the whole of Phase 1; 2.5 on/off and 2.7 dimming adjustments for Phase 2; and 5.2 on/off and 3.5 dimming adjustments for Phase 3. The apparent higher average rate-of-use of the individual control during Phase 3 was, however, due to one single occupant who used the system very actively (50-57 adjustments). The average number of light level adjustments for Phase 3 drops to 2.6 on/off and 2.4 dimming adjustments if this user is excluded. The maximum number of either on/off or dimming adjustments occurring in any other workstation during each period was eight.

During Phase 1, there was a daily average of 3.72 on/off adjustments/day and 5.26 dimming adjustments/day. However, if we exclude the adjustments which occurred during the first week after the lighting system’s reset, these numbers drop to 1.74 on/off and 2.77 dimming adjustments/day. During Phase 2, the number of individual control adjustments dropped even more to an average of 0.99 dimming adjustments/day and 0.61 on/off adjustments/day, which shows that the active occupants used the individual control less frequently when the lighting system was controlled by the light sensor. This suggests that once the occupants selected a light level, if that light level was reasonably well regulated and maintained by the light sensor, the users were satisfied with the selected level for long periods of time. Jennings and others (2000) also noted very little dimming activity after wall dimmers in their study had been in place for more than a year.

Data presented in Table 2 also shows that the awareness campaign (Phase 3) did increase slightly the daily rate-of-use of the individual controls to 0.85 on/off adjustments/day and 1.67 dimming adjustments/day (when excluding the outlier user). However, data also showed that about half of the occupants who used the on-screen controls selected higher light levels, which in turn reduced the overall energy savings associated with this control option, as shown in Table 1. The average daily energy savings from the individual controls dropped from 11% during Phase 2 to only 5% during Phase 3. This was a direct result of the fact that in 20 out of the 44 active workstations in Phase 3, the light levels selected were higher than those recorded during Phase 2, whereas 12 settings were the same as Phase 2, and another 12 lower. We speculate that this was a result of both the occupants being reminded periodically about the lighting controls available to them, combined with a seasonal effect that reduced indoor daylight availability.

Calculated across all 86 workstations, the frequency-of-use of the individual controls was notably low, averaging only 0.02-0.05 control actions (on/off and dimming together) per workstation per day (Table 2).

There was a 5% difference in downlight energy savings from individual control based on workstation proximity to windows (as exemplified in Fig. 8 for Phase 2), with the savings being a little higher closer to the window. This is, generally, consistent with an earlier finding that people manually reduced electric light levels in response to the available daylight (Moore and others 2003). However, in our study this phenomenon was observed only for the period with longer daylight hours (Phase 2, March 12 to October 2).

<u>Two controls scenarios</u>

Data collected during Phases 2 and 3 show that the occupancy control combined with light sensor control would have generated energy savings almost as high as those generated by the system operating with all three controls (estimated average savings of 44-45%). The next best two-control scenario was the combination between occupancy and individual control (average savings of 39-40%). The light sensor and the individual control used together would have saved only 14-24% in energy for lighting, which is 11-24% lower than the energy savings generated by the occupancy sensors used alone. Especially for Phase 2, the period with longer daylight hours, this was mainly because of the downlight's restriction to 50% output when controlled by the light sensor. Nevertheless, during Phase 3, the occupancy sensor remained the single best energy-saving strategy.

5.2.2 Power demand

Data showed that the lighting system also generated significant reductions in the peak power demand for lighting. Table 1 shows the daily average reductions in peak power demand for all phases of the study, for the various control scenarios investigated. When used together, the three controls reduced the daily peak power demand during work-hours on average by 43-49% compared to the same fixtures used at full power (97 W/workstation), and by 65-70% compared to a conventional lighting system (174 W/workstation). This is an important benefit for electric utilities seeking to balance supply and demand at reasonable cost on high electricity demand days (Newsham 2006). Because the controls ensure that not all the installed lighting power is used simultaneously, in this study the installed lighting power density of the studied system (5.6 W/m^2) was reduced to an effective average lighting power density of only 3 W/m^2. This compares very favourably with the 12 W/m^2 allowed for open-plan offices in the widely used ASHRAE 90.1 Energy Standard (2004).

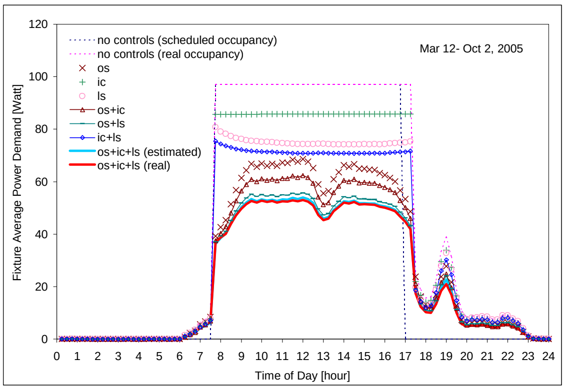

Figure 9 Light fixture average daily power demand for various control scenarios compared to full lighting use from March 12 to October 2, 2005 (Phase 2) during scheduled and total work-hours (downlight restricted to 50% output on light sensor).

Figure 9 shows the average daily power demand profile of the light fixtures during Phase 2. The average peak load was about 53 W/fixture and occurred from 9 AM to 12 AM, and from 2 PM to 4 PM. The average power demand dropped to about 45 W/fixture at 1 PM due to the lunchtime break. The controls also reduced the power demand during non-scheduled hours and during the rounds of the cleaning and security staff.

5.3 Lighting system energy savings potential

Below we present the potential for energy savings and power demand reductions of four system and control alternatives, compared to the one installed.

5.3.1 Option 1: System with static uplights (as installed) and dimmable downlights allowed to dim to zero on light sensor control

As shown in Table 1, if the downlights had been allowed to dim to zero on light sensor control, then the control scenarios incorporating light sensor control only would have reduced the fixture average peak power demand by an additional 7 to 16% for Phase 2, and by an additional 4 to 9% for Phase 3, compared to the actual case.

It is interesting to note that in terms of demand reduction, during Phase 2, the light sensors alone would have performed slightly better than the occupancy sensors alone for most of the workday (39% power reduction compared to 36% from occupancy control alone). Nevertheless, during Phase 3, because of the reduced daylight availability, the occupancy sensors would have still been the single control option with the greatest power reduction.

The average energy savings of the lighting system with all three controls in operation would have been by only 3-5% higher during both periods. Data sorted by fixture proximity to windows showed that in terms of energy use, the light sensor savings would have exceeded those of the occupancy sensors only in the perimeter workstations and only during Phase 2, the period with longer daylight hours. On average, under light sensor only control during Phase 2, the energy savings would have been 12% higher had the downlight been allowed to dim to zero. The savings would have been by only 5% higher during Phase 3.

5.3.2 Option 2: System with reduced power static uplights and dimmable downlights allowed to dim to zero on light sensor control

In this case the fixture average energy savings with the three controls in operation would have increased by an additional 6 to 9% compared to the actual case (Table 1). The fixture average peak power demand would have been reduced on average by an additional 8-11%, the peak power demand being in this case about 40-46 W/fixture. Of course, reducing the wattage of the uplights would have slightly reduced the overall light levels.

5.3.3 Option 3: System with dimmable uplights and downlights, both restricted to 50% output on light sensor control

In this case the average energy savings with all three controls in operation would have increased by an additional 20-22% compared to the actual case (see Table 1). The fixture average peak power demand would have also been reduced by an additional 24%, the peak power demand dropping in this case to about 33-36 W/fixture.

5.3.4 Option 4: System with dimmable uplights and downlights, both allowed to dim to zero on light sensor control

In this case the average energy savings with all three controls in operation would have increased by an additional 23 to 29% compared to the actual case (see Table 1). The fixture average peak power demand would have also been reduced by an additional 29-34%, the peak power demand being in this case between 20-32 W/fixture depending on the season. Uplights, however, are often not switched off with direct-indirect luminaires because this would create an uneven light distribution on the ceiling.

6. Further discussion

One of the goals of this project was to weigh the relative contribution of the three different control systems to the energy savings. Data indicated that if only one type of control were to be installed in this building, and the energy savings and power demand reductions were the principal performance criteria, then the occupancy sensors would be the best choice. As installed, they provided savings in lighting energy use in the range of 30 to 40% compared to full lighting use. Note, however, that these savings were a result of a period of 12 minutes between the moment the last motion was detected and the start of gradual dimming, followed by a period of 3 minutes of continuous dimming before the lights turned off. Changes to either of these two intervals would have affected the energy savings.

Light sensor control ("daylight harvesting") would have provided similar power demand reductions and energy savings to the occupancy sensor control only in the perimeter workstations, only seasonally during periods with long daylight hours, and only if downlight dimming to zero were permitted. On average, the light sensors saved about 10-20% energy compared to full lighting use of the installed system, and 16-32% had the dimming to zero been allowed. Note that data on blind use collected throughout this study showed a high average blind occlusion of the facades of this building of 55%; clearly blind use may strongly affect energy savings with such controls.

If they had been installed independently, the individual controls in this installation would have been the worst single control choice in terms of energy savings (average savings of less than 10% compared to full lighting use), and adding individual control to the system already controlled by occupancy and light sensors provided very little additional energy saving benefit. Nonetheless, the ability of the occupants to choose their own preferred light level remains an important benefit not offered by the other two control types. Individual control has been linked to improved occupant mood, satisfaction and comfort (Newsham and others 2004), and improved environmental satisfaction has been linked to improved job satisfaction (Charles and others 2003). The occupant surveys conducted as part of our larger study supported these earlier findings, demonstrating significantly higher satisfaction for the occupants with the multi-control direct-indirect system compared to those with conventional lighting. Given previous research, it seems likely that this benefit can be attributed to the individual control. The survey results will be discussed in more detail in a future publication.

Table 1 illustrates that the energy savings from two or three controls used together (os+ic, os+ls, ic+ls, os+ic+ls) are not equal to the sum of the savings of the controls when used separately (os, ic, ls). This has a straightforward explanation, but one which is often not appreciated. For example, if an occupancy sensor would save 40% on its own, and a light sensor 20% on its own, the saving with both sensors is not 60% (40% + 20%), but somewhat less. The light sensor cannot contribute energy savings during the period when the lighting has already been switched off due to occupancy. Similarly, the occupancy sensor could not claim all of the savings during absence if daylight harvesting would have reduced the lighting load during that period anyway.

Note that we did not attempt to analyze the effect of the lighting energy savings on the thermal energy use in the building. Reducing lighting energy use means reducing the internal heat gains. During the cooling season, the lower internal gains will reduce the cooling load, which is also an electrical end use. However, in the heating season, the internal gains would have to be made up by the heating system, which was fuelled by natural gas in this building. In general, the overall thermal effect will depend strongly on the local climate, the building design and properties, and the characteristics of the building HVAC system (Newsham and others 1998).

It is also important to note that the lighting system in the studied building was maintained and operated by a highly qualified and motivated employee. This likely played an important role in realising energy savings of the magnitude reported here.

7. Conclusions

The results of this study are drawn from long-term data of a single building using a particular lighting system. This lighting system was a workstation-specific, 3-lamp direct-indirect system with integral occupancy and light sensors, and individual dimming control. The three controls affected the light output of the two lamps directed downwards, while the single lamp directed upwards was always on during scheduled occupancy. Despite the specifics of this field study, we believe the following findings are likely helpful to general office lighting practice:

- Due to its reduced lighting power density alone, the direct-indirect lighting system saved 42% in lighting energy use compared to the static ceiling-recessed system it replaced. With all three controls in operation, the lighting system saved an additional 42-47%, which translates into energy savings of 70% compared to the conventional lighting system.
- If the three lighting controls systems had been installed separately, occupancy sensors would have saved, on average, 35% if used alone, light sensors (daylight harvesting) 20%, and individual dimming 11%. The light sensor savings were, of course, higher in perimeter workstations, and would have matched the performance of occupancy sensors on the perimeter if the downlights had been permitted to dim to zero under light sensor control, rather than to only half output.
- There were concomitant reductions in peak power demand for lighting. The three controls reduced the average daily peak power demand by 65-70% compared to a conventional lighting system, and by 40-50% compared to the installed fixtures used at full power. This is an important benefit for electric utilities seeking to balance supply and demand at reasonable cost on high demand days.
- The peak power reductions due to the controls meant that the installed lighting power density of the system (5.6 W/m^2) was reduced to an

effective average lighting power density of only 3 W/m^2.

- Several other design/operation options that would have further reduced lighting energy use were identified: allowing the downlights to dim to zero instead of only 50% output when under light sensor control; reducing the wattage of the uplights; or controlling the uplights identically to the downlights. However, design options including the uplights risk greater ceiling non-uniformity.
- Occupant surveys conducted as part of our larger study demonstrated significantly higher satisfaction for the occupants with the multi-control direct-indirect system, compared to those with conventional lighting. Given previous research, it seems likely that this benefit can be attributed to the individual dimming control.

Overall, the results of this field-study show that lighting systems incorporating both automatic and personal controls have the potential to realize considerable energy savings and peak power reductions in open-plan environments, while being at the same time positively perceived by the occupants.

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PROMOTING HIGH QUALITY CFLs ACROSS EUROPE: THE MAJOR OUTCOME FROM EnERLIn PROJECT

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Abstract. *To ensure a sustainable growth and use of Compact Fluorescent Lamps we propose to develop valid promotional arguments and implement coherent promotional campaigns; to train end-users in order to achieve a self-sustained CFL use growth. To achieve considerable savings in this sector, a coherent strategy is required to transform the lighting market. To ensure a sustainable growth and use of CFLs, the partners of the EuropeaN Efficient Residential Lighting INitiative (EnERLIn Project EIE Programme, SAVE) have developed valid promotional material and implemented coherent promotional campaigns to inform and train end-users in order to achieve a self-sustained CFLs use growth. Thus, EnERLIn project objectives is to substantially increase the efficiency of residential lighting in a number of Member States and Candidate Countries, through increased penetration of CFL's in the residential sector. This paper give some insight on results obtained by this 3-year project that execution has been achieved in December 2008. The results presented here are mainly concern the analysis of CFL market barriers and especially quality issues as well as dome examples of CFL promotional campaigns that have been undertaken in order to discard the barriers.*

Keywords: CFL promotion; Energy Efficiency; CFL quality

Introduction

Lighting consumes 14% of all electricity consumption within the EU and represents a big energy saving potential still of 20% on all the lighting currently installed in Europe. Old and inefficient lighting technology consumes large amounts of unnecessary energy, creates a cost burden both for local authorities, business and tax payers and produces large and unnecessary amounts of CO_2. Furthermore, energy savings from CFLs, by replacing only one additional GLS lamp by one CFL per household a gain of 11 TWh corresponding to 1.2 Mtn of less CO_2 per annum can be achieved.

To achieve considerable savings in this sector, a coherent strategy is required to transform the lighting market. The consortium work is focussed on the better promotion of Compact Fluorescent Lamps for residential use. The overall project objective is to substantially increase the efficiency of indoor residential lighting in a number of EU Member States, through increased applying of CFLs in this sector.

EnERLIn project used the maximum of the consortium competences in order to address the following issues:

- Quality standard: The output from the European CFL Quality Charter is now updated and used, in addition several

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consortium members are National Energy Agencies and they have the possibility to transpose CFL-QC standard in their countries.

- Identify Negative arguments that potential individual users may oppose to CFLs, this issue is perfectly addressable in EnERLIn by passing trough surveys and questionnaires individual users as well as to professionals that they are in contact with clients and collect “complaints”.
- Scientific Arguments: The consortium includes some academic institutions that are contributing to the elaboration of unified protocols that should be used in test centres. In parallel, some consortium members have yet CFL test installations that may be used for the project aims. Finally a unique test facility has been created under the coordination of the academic institutions and with the collaboration of National Energy Agencies.
- Training: The consortium has all necessary competence in this domain. Academic institutions can help to the creation of curricula and test them in local scale. The definition of these curricula is done jointly with all other members of EnERLIn consortium who are aware of real needs in the domain. ENEA created the e-learning modules supervised by academic institutions.

Attractive material for promotional campaigns for CFLs: The consortium used all collected material and experience in order to define promotion campaign scenarios. The consortium defined the type of promotion media that driven each campaign. Some preliminary tests-campaigns have been executes in small scale in order to test a concept before use it in a real scale operation. Thus, all parameters concerning the campaign have been tuned and then the promotional material creation was outsourced to communication professionals.

Analysis of barriers for further implementation of CFL´s

An important task in the frame of EnERLIn was to understand why end-user avoids (or dislikes) CFLs for residential use. Analysis of possible barriers to implement CFL´s has been carried out in order to understand the human mechanism regarding willingness and avoidance to implement CFL. The result showed that around 30% households do not want to have CFL´s in their home and that reasons for not having CFL´s are many. Further a range of action plans for increasing the use of CFL´s in Danish households has been evaluated and a realistic potential for increasing the number of CFL´s has been considered.

The consortium complied information, from various sources including direct population inquires, and established the following list of barriers:

- Consumer dislikes classic CFL shapes, and, CFLs misfit often to “design” luminaries
- Consumer dislikes colour temperature & rendering of CFLs
- Good quality CFLs are still expensive, and, inexpensive CFLs aren’t reliable
- Return time on the consumer’s investment is short but not directly observable in a periodic electricity invoice
- Plug & Play CFLs aren’t dimmable
- Consumer need all light instantaneously but CFLs need time to warm-up

- CFL dislikes rapid (or random) ON-OFF cycle and is incompatible with presence detectors
- CFL power supply dislikes mains voltage fluctuations
- Payback period can be long when electricity is price is artificially low (this the case of some eastern countries)
- Some concerns about UV radiation escaping from the tube are also expressed.

It should be noticed that beyond classic barriers identified up to now, a new one appeared during the last months: danger due to electromagnetic wave interactions with the human tissues. This has been put in front from some NGOs especially in countries like France; however, there is any plausible proof of any danger linked to the power supplies incorporated in the lamp cup.

Another point that seems to cause problems for CFLs is that they contain Hg. This is of course true but it should be known that if Hg-free lamps (using essentially Xenon) replace existing CFLs the energy quantity necessary, for producing the same quantity of light, would be multiplied by a factor of 2-2,5. Today, the quantity of mercury inside CFLs is in net decrease (in the order of 2 mg/lamp when EU RoHS allows a maximum of 5mg). In addition, all EU countries have CFL recycling obligations. In many cases (France, Germany, UK…) the recycling circuit is well organized and effective. For example in France Recylum, within just few years since its creation, recovers and treats more than 30% of mercury-congaing lamps It is clear that in this domain more information in destination of the end-user is necessary.

The first results from the questionnaire distributed before and after the Jelgava campaign in Latvia pointed out that efficient information could wave-out some "barriers" like shape but then, as shown the Figure 1, consumers become more demanding on Quality and colour issues. In many westen countries, CFLs residential end-users are much more concerned by the light quality (colour temperature, colour rendering, light stability) and lifespan than CFL retail price. In contrast, in Eastern countries, like Latvia, price is still the major brake. However, in Bulgaria, the main reason for customer dissatisfaction is the low quality and low lifespan of the lamps. In fact, in Bulgarian market customers could find mainly cheap but low quality CFLs. Usually these low quality lamps are coming from small factories in Far East countries that don't respects international manufacturing standards. In fact these low quality products flood the market and damage seriously CFL reputation to the eyes of the individual end-user; this is a major issue for all countries. It should be noticed also that we observed that almost half of the probed population are not aware of the fact that the saving allows the recovery in a year of the initial whole investment. Again, reliable information is cruelly missing.

We found that people with high educational level know about CFLs use them extensively even if there is some concrete dissatisfaction due to both low light quality and unexpected low lifespan. It should be also noticed that especially the elder population is not informed about CFL (thinking the price is 3 or 4 times higher than it is actually in shops), and that is why they do not use them. However, for people staying at home most part of the day, power savings and costs could be very significant.

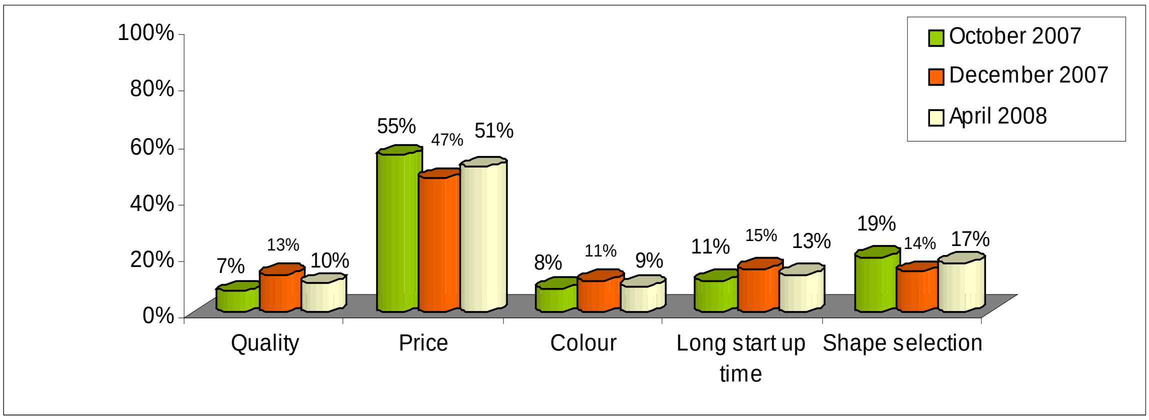

Figure 1 *Answers on market barriers as obtained in Jelgava (Latvia)*

CFL-Quality Check & Monitoring

A CFL-Quality monitoring has been carried-out in ENEA (IT) and UPS (FR). The monitoring campaign has been performed during one year. The tests aimed to evaluate the ageing of CFL in a simulated real-use environment, and are based on EU standards and Quality Charter. Tests are performed on more than 100 CLFs (the most common powers) from different brands, under different environmental conditions (i.e. in climatic chamber).

Both partners worked on the establishment of a common testing method. This method is directly inspired by EU standards and CFL Quality Charter requirements. The following quantities have been monitored:

- Light output is measured at the beginning phase of the tests (after initial controlled ageing of 100h) and then regularly checked.
- Lifespan for series of on-off cycles operated
- At the end of the test light output (on the survivors samples) is performed again.
- Colour coordinates and colour temperature variations.

The tests evaluated the behaviour of CFLs with ON - OFF operation, under different temperature stress (i.e. very cold, e.g. balcony, garage, outdoor in winter time or very hot, e.g. closed luminaire in a kitchen during summer time...). Different testing condition and cycle sequences have been investigated, following the CFL quality Charter and then the Directive 2005/32/EC (Ecodesign for Energy Using Products) voted on Dec. 8, 2008.

Results are available for cycling sequences:

- according to Quality Charter (5 min ON, 10 min OFF, 25°C ambient temperature)
- Ecodesign (1 min ON, 3 min OFF, 25°C ambient temperature)
- with cycles 5 min ON, 10 min OFF, 40°C ambient temperature

The figures 2a and 2b illustrate some of our results for light output depreciation of various CFL brands (under standard cycle as defined by EN60969) as well as the failure rates under various fast ON-OFF cycles. In all cases rapid ON-OFF cycle is linked to higher failure rate but the increase of failure rate is moderate in the case of high quality lamps. The increase of failure rate can be explained by the fact that in rapid ON-OFF cycle electrode sputtering is increasing (especially when electrodes are cold on/and not preheated). Low quality CFLs are using electrodes coated to an uncontrolled way and this is directly responsible for more failures under the same conditions.

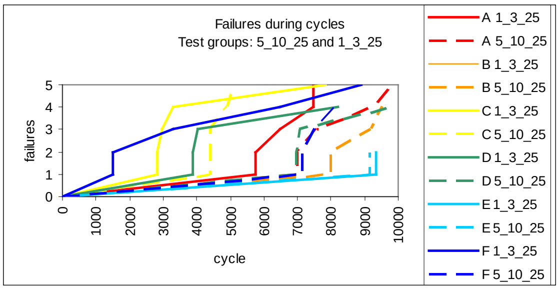

Figure 2a *Failures observed as function of lamp age for different ON-OFF cycles. A, B,…F correspond to various brands. The numerical notation "x_y_z" correspond to: x: ON time in minutes; y: OFF time in minutes, z: testing temperature*

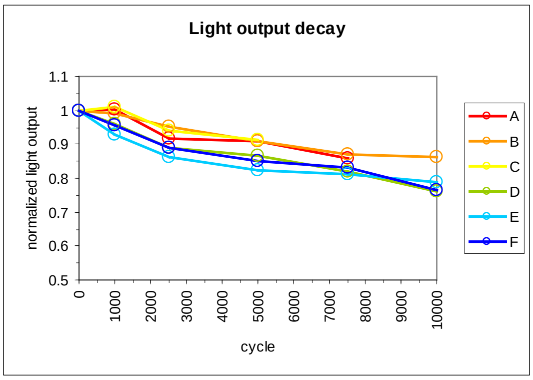

Figure 2b *Lumen output depreciation as function of age for different brands under standard ON-OFF cycle*

High Quality CFL Database

EnERLIn consortium produced databases with high quality CFLs and luminaires. Both databases are searchable and accessible via the project web page.

The High Quality CFL Fixture Database is made based on existing inventories of such luminaries, but mainly on the input from the lighting manufacturers and their trade associations in the EU. A crucial target was an excellent quality of the interior pictures of the fixtures, in order to have a tool which can and really should be used by consumers and lighting specifiers to make a (first) selection of (a) fixture(s). A database has been created (www.e-ster.be/enerlin) and a selection of energy-efficient lighting fixtures has been put into it. The database contains 122 suspended fixtures and 16 up-lighters; for each entry the following data are included:

- one or more pictures
- the name of the lighting fixture
- technical information (type and number of lamps, colour, description)
- the advised price
- the contact data of the manufacturer.

In parallel, within the German climate protection campaign "Klima sucht Schutz". we developed an online-tool: the "High Quality CFL Database". This database gives technical characteristics of about 300 compact fluorescent lamps and halogen spots in both English and German languages. All listed CFLs respect the rules imposed by the CFL quality charter.

The online tool helps to find the appropriate lamp and compares several lamp types with each other and reveals energy saving potentials. The Federal

Ministry for the Environment promotes the publication of the online offer.

This database is similar to the database for energy efficient light bulbs developed for TopTen (http://www.guide-topten.com/) but it is fundamentally different that because its aim is to include a number of CFLs as large as possible and not only the 10-best examples. The products are ranked by efficiency and it is possible to do direct comparison of 2 - 3 products. Comparison of life-cycle-costs, based on: Energy consumption; Retail price; Typical usage and energy prices. Today, 2,000 to 5,000 connexions are registered per month.

Promotional campaign Design

The most important outcome from EnERLIn project is the design and testing of various CFL promotional campaigns. it is important to realise a promoting campaign in order to better present and inform the end-users about the qualities and benefits of CFLs.

To achieve this objective several steps were necessary:

- Probe the end-users and retailers using specific questionnaires in order to be able to evaluate campaign impact.
- Elaborate various campaign scenarios adapted to different target populations.
- Creating attractive promotional materials and tools.
- Collect results and analyse the impact for different campaign strategies.

Questionnaires are an easy way to gather information. We believe that we can collect mostly qualitative information from questionnaires, rather then quantitative information. The questionnaires, if there are well designed could then provide very useful information on the following points:

- Segmentation of the market
- Knowing and using the object
  End-user behaviour knowledge: future purchase and influencing factors
- Experience and satisfaction of the user
- What are the preferred information sources

This way has been chosen inside the EnERLIn project to collect information on CFLs in household environment from two different points of view: those who use CFLs (end-users; the demand side) and those who offer CFLs (manufacturers, retailers etc; the supply side).

One important outcome from EnERLIn project is the creation of a document that includes various questionnaires for end-users and CFL-professionals. Partners develop the questionnaires in various languages for covering various situations. This global document is available in the project web page.

Exemples and lesson learnt from national campaigns

The objectives of the German Campaign were the dissemination of efficient lighting systems in private households and also in the tertiary sector. The campaign “energy saving lighting” pursued the following targets:

- Improvement of the information and motivation about technologies and implementation strategies for efficient lighting for private users, decision makers of public authorities as well as companies in the service sector and industry.

- Overcoming of implementation barriers for the utilization of CFLs and lighting refurbishment.
- Support of marketing activities of lighting services companies due to their key role in lighting refurbishment.

A series of workshops about energy efficient lighting has been held in five regions in Germany in cooperation with regional partners. The target group of the series were public authorities. The direct addressing of target groups was complemented by initial consultations to topics such as financing, funding, and technical implementation. The consultations focussed on the implementation of good practice examples.

The campaign improved the marketing activities of manufacturers and energy service companies (ESCOs).

The participants of the campaign reported their appreciation of Best Practice, workshops, CFL Data Base and considered it important for the energy efficiency in lighting systems. Good-practice examples are currently not very well known and we can consider that the German campaign has improved the communication of such to a high extend. Private consumers are interested in information about the quality of CFLs, affection by switching and colour rending.

Latvia carried out a CFL promotion campaign “More light for less money” in the municipality of Jelgava. The main promotional activities concerned:

- Drawing, comics and energy saving calculations competitions for school pupils.
- Information days for Secondary schools.
- Informative stands in Point Of Sale (POS) and workshop for POS people.
- Distribution of booklets for inhabitants of Jelgava.
- Information about campaign in mass media.

Campaigns in schools involved 605 pupils, distributing posters and booklets completed with important information about efficient lighting and CFLs and what to do with the end of life bulbs. During the campaign, not only the pupils have been informed about energy efficient lightening, but also there teachers and other people that came to the schools. And one of the best ways to change people behaviour and think environmental friendly is to start with children because they are open to new information and can also affect their parents’ opinion. A campaign-closing event was organized including the award of winning pupils that participated in the competitions and a summary of all activities that carried out during the campaign.

Ten shops from Jelgava decided to participate in the campaign and put in the shops informative stands with booklets about energy efficient lightening and energy efficient lamps with action prices.

For the campaign on the streets about 20 000 leaflets have been prepared and distributed by campaign endorsers with the campaign T-shirts.

During the distribution also explanation to people about the aim of the campaign and about energy efficient lamps were given.

To reach a wider audience about the campaign information about CFL and energy efficient lightening campaign “More light for less money” the Mass media such as Newspapers, Radio, TV broadcast and home page of the Municipality were involved. The campaign involved Philips Latvia, Osram, Ekogaisma and Plaza, which sponsored with free CFLs and reduced prices. The positive results of the campaign impact to citizens, shows that such campaigns are needed and can be implemented in other municipalities.

Italy performed two campaigns: The first was dedicated to a face-to-face promotion of the CFLs and organized in occasion of the School Day held in Italy on the 23rd of March 2008, where ENEA, the JRC of Ispra and Teaching Regional Direction collaborated. Over 1100 children from 25 Italian schools visited the JRC-Ispra site. The young guests in the age between 9 and 18 and each of their schools were given the opportunity to choose the laboratories, installations and presentations they wanted to see. More than 250 students coming from secondary schools and higher education, divided in 6 groups attended the Laboratories of ENEA.

At that occasion, the questionnaire has been used. It was prior sent to the teachers in order to make the students fill them out before the visit. More than 150 students handed them back and received a free CFL and the booklet “Energy saving with lighting” edited by ENEA. The evaluation of the questionnaire reported that the total lamps installed are in average 20.5 out of which 4.1 are CFLs and most of them are installed outdoors. The majority of the families were satisfied with CFLs’ light intensity and lifetime, 44% with CFL light colour.. Negative comments were addressed to a “too cold light” from CFLs. In addition, final users reported that slow switching time could be seen as an “inconvenience”. However, it can be accepted in name of environmental and economical benefits. A change of habits was observed: Lights are always switched “ON” for at least 5 minutes and they are switched OFF only when nobody will reasonably use the room anymore. This change of behaviour is linked to the fact that end-user is more and more aware about the problems arising with rapid ON-OFF cycles. However, this change of behaviour could have a negative impact on energy consumption. An estimation of the energy use should be performed taking into account the usual lighting durations observed in various rooms (ling room, toilets, kitchen etc…), unfortunately this a very hard task because crucial and reliable data are missing.

The second Italian action was a web-based campaign using the ENEA developed e-learning platform (http://odl.casaccia.enea.it). This campaign was addressed at national level several categories of individual end-users (students, teachers, citizens, decision makers) as well as institutions like Universities, schools and training other organization. The web campaign involved 388 users coming from all over Italy. With respect to the education level, 62% of the users had a University Degree, 34% came from high school. Of them 69% were engaged in technical field.

In Poland Approximately 100 000 final users have been reached by the CFL campaign. The campaign was successfully as defined in general education program base. It was not so easy to discover financing way to continue the campaign around whole country. More especially, we prepared and produced a wide promotion campaign around schools. Energy efficient lighting problems are interesting for students but not well known so far. The project realization has not only educational value but school society integration feature too. Teachers and students have assessed the concept of the module “Efficient lighting” and its utility in the educational process with high importance.

A training day was organized for 600 teachers giving them the set of the materials (DVD film, Guidebook for students, Guidebook for teachers, poster). Over 20 thousand students received the information regarding CFL usage at home, climate changes and GHG emissions. Afterwards, a CFL Promotion campaign ”Effective lighting”, was prepared in five schools for two education levels: a secondary school and a higher education.

The module "Efficient lighting" has been defined as evaluation object. The procedures used to collect the information are Interviews with the teachers and students, Observation of the activities carried out at the chosen schools and questionnaires completed by the teachers together with students using the module "Efficient lighting”.

In Sweden, Respect has made a priority to bring the main partners together to create a platform for a successful implementation CFL campaign across the contry and coordination with international partners. The design of a campaign for Swedish market together with the Swedish Energy Agency was based on standards for CFLs. A platform for standardization guidelines was prepared for the implementation of a strong network with the distributors of CFLs. A promotion and standard leaflet was designed, based on a Danish leaflet and printed in 25 000 pieces and later up to 150 000 pieces). The leaflets were distributed through the market partners as IKEA and other retailers. A follow-up meeting was held, with the purpose to establish a standard market group with members from all main retailers. The brochure titled ”Energy efficient and good residential lighting”, guides the readers to successfully illuminate their homes “function by function” and “room by room”. In 2008 this brochure was disseminated to 900 000 clients of the largest Swedish utility Vattenfall. Furthermore, Fortum another large Swedish utility disseminated the brochure to 850 000 of its clients. Amongst the housing societies HSB through its 3900 housing society members disseminated the brochure to over 200 000 of its condominium owners.

In addition the “Road to Copenhagen” event has played an important role in spreading the message from the EnERLIn project. The website was viewed by 2722 visitors coming from 77 countries. The conference “Road to Copenhagen” held in Brussels reached also more than 150 decisions makers.

Danish Energy Association stated that they were not able to carry out an information campaign but they have calculated six possible scenarios stating that scenario analysis is a very important tool to get at clear picture of what is reachable in the future CFL market. These scenarios have been developed in order to assess the maximum energy efficiency potential for lighting in Denmark including the maximum number of CFL that can be installed in Danish households. Further more, the Danish Partner has started a process for Energy savings project including technical development of new applications. The experience shows recommended assessment methodologies for electricity companies working with information campaign activities aiming to increase the penetration of CFL into the market and addressing it to the end-users.

The 10 Bulgarian Campaigns organized by Sofia Energy Centre were called "quality" and addressed citizens, decision makers, installers, other professionals and sellers. The CFL campaign was addressed to about 2.5 million of final users through leaflets, TV broadcasts and newspapers. The Bulgarian partner involved the ENERLIN Consortium, the National Committee on Illumination and CEZ Electro Bulgaria. A successful element of their activities was the increased market of CFLs by 15%, a weak element the higher price of CFLs. In the future, they are planning to phase –out Incandescent Lamps.

The end-users inquiry was executed through random telephone calls. The number of people contacted was about 500, from them 200 replied. The main conclusions are:

- 74%, of the population do not have a single CFL;
- The average number of lighting points in a household is 14;
- The average number of CFLs for a household that has such is 2.5 lamps;
- To the question "Do you know anything about CFLs" 60% of the questioned people responded "Yes" and 40% responded "No"'
- 80% are not satisfied with the CFLs.

A second inquiry was addressed to the importers, retailers, architects and designers. Of all the questionnaires handed out, 20 returned filled in. The following results from the inquiry should be underlined:

- The ordinary incandescent lamps have the biggest share on the market. Second come the halogen lamps, and third – CFLs.
- To the question "To what an extent do the existing luminaries for incandescent lamps prevent their change with CFLs?" 21% replied to a large extent, 43% think that this is not of such a great importance and 36% that this is not a big deal.
- In recent years, mainly the low quality manufactured lamps were sold because of their low price. Their bad reputation, however, decreased people's interest towards CFLs. At present, the interest towards quality European lamps is growing.

The Czech republic CFL Campaign reached over 4 million final users at national level. Philips Lighting Cz, Osram Cz, Ekolomp and South Bohemian Regional Energy Agency were involved. Philips, Osram, Ekolamp and the Ministry of Industry and Trade sponsored the initiative co-financing the production of promotional materials (leaflets and info packs). On the web, promotion of the good quality of CFLs was made. Eight types of leaflets were printed and distributed, over 50 articles were published and TV and Radio involved.

In addition a specific survey has been implemented in two specialized shops on the light sources and lamps, with high expertise and assistance availability. The target group was educated consumers, often professionals, who visit these shops. However, they also include general public. The survey was undertaken in the period of January – April 2007. Up to now, 2000 copies of papers have been distributed and some 400 have returned. The inquiry showed that some two thirds of the survey participants do have at least one CFL at home. From those households, which have at least one CFL at home, they have on average 3 pieces of CFLs installed. On the other hand, in a typical household the number of light points is 15, so there is a definite potential for at least some more CFLs to be installed. Regarding the qualitative aspects of the CFL usage, only one third of respondents feel that they have sufficient information on the CFL quality aspects. Some 66% think that the shape of lamps and luminaries prohibit the wider usage of CFLs. A majority of the respondents agrees that CFLs reach the declared lifetime (70%), and that the higher purchasing price is appropriate (62%). Of the respondents, 65% do like the colour of light of the CFL bulbs and 40% consider the energy efficiency to be as high as declared.

In Romania, the technical University of Cluj Napoca was partner of two programs, namely EnERLIn and CREFEN, targeted to the energy efficiency in residential buildings lighting. Subcontractors were involved in the survey and the dissemination of the activities. The campaign organized addressed end-users, dealers, architects and electric and lighting installations designers. The questionnaires for end-users were designed in such a manner that half part remained to the people as an information support on the EnERLIn programme, the parameters and advantages of the CFLs use. The main difficulties in the campaign was to persuade people to answer the questionnaires. Special attention was dedicated to the young generation and the over 50's. Also, special attention was given to the promoters of new projects, mainly for residential buildings, Architects and Electric-Lighting Installations Designers. Thanks to their positions to educate the professionals and to improve their knowledge to promote the CFLs use in residential buildings.

In 7 CFL campaigns, 892 final users were involved. The diffusion was 50% local, 17% regional and 33% national. Furthermore an average number of CFLs per household is 2.8. It has been seen that end users who live in urban areas and those who have higher education mostly know CFLs. They have replaced the normal lamps with CFLs especially in the places where the lamps are mostly used. In rural areas, especially in the villages that are very far away from the city, there is a lack of information concerning the quality of CFLs that leads to not using them. We estimate that elder population is not informed about CFL (they think the price is 3 or 4 times higher than it is actually in shops), and that is why they do not use them. According to the questionnaire answers, people do not know the durability of CFLs the payback time.

The Hungarian partner carried out a national survey to examine the use, the attitudes, behaviour, knowledge of and experiences with CFLs of the consumers. The pilot campaign was organized in 3 different kinds of units of the retail market. Shop assistants were trained, a simple message chosen. Campaign material was placed at the entrance and at the shelves. In case the customer bought a CFL and filled in the questionnaire, he would get a free CFL. The campaign lasted 3 weeks. In the shop of the GE Lighting - Tungsram, the campaign was successful; customers were conscious and looking for good quality goods and invested in CFLs. In department stores, shop assistants were generally too busy. The only feasible action to promote environmentally friendly technologies was to “hide” the traditional incandescent lamps in low, backside shelves. In hypermarkets, the campaign was a complete failure. Shop assistants did not collaborate with the promotion of CFLs distributing leaflets and information as it was considered as a kind of extra activities.

The inquiry showed that the main reason for buying CFLs is the reduction of energy consumption. It should be noticed that 60% of the people are expecting more reliable information about CFL benefits. In fact, 93% of the people asked found it useful and of high quality.

Conclusions-lesson learnt

EnERLIn project allowed to design and test several promotional campaigns for boosting CFL acceptance by residential users. The campaigns have been specifically designed for reaching various target populations in different European countries. Several million people across Europe have been reached. The collected results allowed to better identifying the barriers that impede CFL acceptance by the population and also probe reactions to various promotional stimuli. The following main lessons are learnt for the 3-year project execution:

- Artificial light generation is a fundamental need for human being. This seems to be a very general lesson, however it has a very strait forward incidence to all Energy Efficient Lighting schemes that can be proposed for implementation: end-user is very conservative and reluctant to new lighting solutions especially when they don’t satisfy some aspects related to quality of life. Energy saving due to light is considered as important by population but it pass always is second plan after quality of life and comfort. This implies that, especially in Residential sector any EEL project for market transformation has to take into account this behaviour otherwise it condemned to fall.
- End-user is very regarding on CFL Quality. Low quality devices “pollute” the market and seriously impede the increase of market penetration of that energy efficient technology. A systematic CFL-quality control is imposed in EU level following a well-defined unique testing protocol and associated with readable and compulsory labelling.
- There is a significant lack of knowledge and data on the penetration and the trends in use of various lighting technologies in households. This is especially true in Eastern European countries, therefore it is difficult to clearly articulate what we would like to achieve with a campaign and whom exactly we could target in order to increase efficient light sources penetration.

Today, incandescent lamps are banned and population is somehow pushed to adopt CFLs, however, the lessons listed above have to be taken into account for the promotion of the next generation of light sources: the Light Emitting Diodes. In fact CFLs have been "pushed" to the market when the technology was not enough mature, more than 30 years needed in order to "convince" people that this product is now matured but quality issue still a real problem. We hope that this error will be avoided for LEDs…

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09.30 – 10.00	Participants registration
10.00 – 10.20	Messages
	INVITED LECTURES SESSION Opening Lecture
10.20 - 10.50	Honorary Professor **Axel STOCKMAR** President of the CIE National Committee of Germany Energy efficient railway lighting according to the European standard EN 12464-2 *HP Axel STOCKMAR has participated at all International Conferences ILUMINAT 2001-2009*
10.50 - 11.10	Professor **Cornel BIANCHI** President of the CIE National Committee of Romania Modern structures of using natural light for natural-electric integrated, efficient and quality lighting systems
11.10 – 11.30	Professor Ir. **Wout van BOMMEL** Philips Lighting, Eindhoven, The Netherlands Fudan University, Shanghai Past president CIE Board IDA Road lighting in the light of the future
11.30 – 12.00	Coffee break
12.00 – 12.15	**Dr. Grega BIZJAK***, **Dr. Matej KOBAV,** University of Ljubljana, Slovenia *President of the CIE National Committee of Slovenia Consumption of Electrical Energy for public lighting in Slovenia
12.15 – 12.35	Dr. **David CARTER**, Reader, University of Liverpool, UK Hybrid lighting systems
12.35 – 12.50	Professor **Cătălin D GĂLĂȚANU,** Ass. Professor **Dorin D. LUCACHE** Technical University "Gh. Asachi" of Iasi, Romania Point of view: quality in lighting education
12.50 – 13.10	Professor **Liisa HALONEN**, Head of the Lighting Laboratory Dr. **Eino TETRI** Helsinki University of Technology, Finland Lighting Efficiency and LED Lighting Applications in Industrialized and Developing Countries
13.10 – 13.25	Professor **Virgil MAIER,** Professor **Sorin Gh PAVEL**, Head of the EPS Department Technical University of Cluj-Napoca, Romania Flicker dose in the road lighting
13.25 – 13.45	Dr. **Janos SCHANDA**, Professor emeritus of the University of Pannonia, Hungary **Katalin GOMBOS** Photometry of Solid State Lighting in theory and practice
13.45 – 14.00	**Şerban ŢIGĂNAŞ,** President of the Order of the Romanian Architects, Transylvania Branch **Dana OPINCARIU** Technical University of Cluj-Napoca, Romania What the architects are expecting from the artificial light?
14.00 - 14.15	Professor **Florin POP**, Head of the Lighting Engineering Center Dr. **Dorin BEU**, Reader Technical University of Cluj-Napoca, Romania Ten years of sustainable lighting in Transylvania
14.15 – 14.20	**Award of the Best Paper of Ph.D. students**

Proposed papers - *The author is a Ph.D. student

P1 Albu, H.O.*, Pop, F., Technical University of Cluj-Napoca, Romania
Power Quality analysis of buildings lighting installations

P2 Barb, D.C.*, Pop, F., Technical University of Cluj-Napoca, Romania
KNX and DALI – Controlling the light

P3 Barb, D.C.*, Ştefănescu, S., Martineac, Corina, Technical University of Cluj-Napoca, Romania
Rehabilitation of Lighting Installation of Central University Library - Energy Efficiency Case Study

P4 Bindiu, R.*, Cziker, A., Pop, G.V.*, Technical University of Cluj-Napoca, Romania
Optimum Tariff Selection for Public Lighting Systems

P5 Bucur, Gh.D.*, Sarchiz, D., University "Petru Maior" Târgu Mureş, Romania
Optimization of reliability electric supply of hospital emergency lighting

P6 Bucur, Gh.D.*, Sarchiz, D., University "Petru Maior" Târgu Mureş, Romania
Evaluation and optimization criteria of reliability electric supply of emergency lighting

P7 Ciugudeanu, C.*, Pop, F., Technical University of Cluj-Napoca, Romania
Tubular daylight guidance systems - Energy Saving Potential in Residential Buildings in Romania

P8 Cziker, A., Chindriş, M., Miron, Anca*, Technical University of Cluj-Napoca, Romania
Implementation of Artificial Intelligence Techniques in Lighting Systems

P9 Dumitru, Cr., Gligor, A., University "Petru Maior" Târgu Mureş, Romania
Renewable Energy Laboratory for Lighting Systems

P10 Gecan, C.O.*, Chindriş, M., Bindiu, R.*, Technical University of Cluj-Napoca, Romania
DC Voltage Lighting Systems

P11 Grif, H.Şt., University "Petru Maior" Târgu Mureş, Romania
Neutral daylight control system

P12 Grosuleac, D.*, Philips Romania
Design principles for cove lighting

P13 Ignat, J., Technical University "Gh. Asachi" Iaşi
Considerations regarding the supply solutions of the safety illumination system – type 2a (in Romanian)

P14 Martineac, Corina, Ştefănescu, S., Hopîrtean, M., Technical University of Cluj-Napoca, Romania
Dealing with light pollution

P15 Pop, G.V.*, Chindriş, M., Gecan, C.O.*,Technical University of Cluj-Napoca, Romania
Oportunities to Reduce Consumption of Electricity in Lighting Systems

P16 Rosemann, A., Şuvăgău, C., BC Hydro, Canada
Model to Determine Lighting Energy Savings in Commercial Buildings

P17 Ştefănescu, S., Martineac, Corina, Barb, D.C.*, Technical University of Cluj-Napoca, Romania
Photovoltaic Architectural Lighting - Central University Library Case Study

P18 Szabó, Erzsébet, Buzura, Anca, Mocan, Al., S.C. Pieme S.R.L., Cluj-Napoca, Romania
Problems and proposals for sustainable lighting solutions for special areas of historical monuments, according to EU directives to reduce energy consumption

P19 Ţicleanu, C., "Transilvania" University of Braşov
Approach on modelling of horizontal daylight transfer by light-pipes and anidolic ceilings

The ad-hoc Jury formed by the Invited Lecturers and the Lighting Proffesionals with Presented Papers decided to offer the Award of the Best Paper by a Ph.D. Student to the proposed papers of Ciugudeanu Calin - P7, Tubular daylight guidance systems - Energy Saving Potential in Residential Buildings in Romania, and GECAN Calin-Octavian - P10, DC Voltage Lighting Systems.
Their papers will be published in the INGINERIA ILUMINATULUI journal, nr. 23 – Summer 2009 and 24 – Winter 2009.

The 5th International Conference **ILUMINAT 2009** Cluj-Napoca, Romania provided a special forum to discuss and debate the latest developments in energy and environmental impact of lighting systems, the policies and programs adopted and planned, the strategies to be implemented to further progress, as well as the technical and commercial advances in the dissemination and penetration of energy efficiency in lighting.

The target audience represented the community of lighting professionals including lighting and building science researchers, engineers, system designers and project managers, academia and experts, architects and urban planners, local community representatives, students.

The Conference included Invited Lectures of Axel Stockmar, Cornel Bianchi and Wout van Bommel, to present their views, programs and research to advance energy efficiency in lighting. The Invited Lectures and papers submitted by other participants on specific themes and topics were printed in the Conference Proceedings (http://users.utcluj.ro/~lec) and will be selected for the INGINERIA ILUMINATULUI journal.

The Conference allowed the best knowledge of new policies and strategies to increase energy and economic efficiency, to mitigate climate change and to faster sustainable development, to build international partnerships among lighting professionals, to emphasize their cooperation.

In his message, Franz Hengstberger, President of CIE underlined that *"On the occasion of your upcoming conference, allow me to convey to you the best wishes of the CIE. Your conference comes at a trying time for international trade and many national economies. This global crisis has an impact, which affects nearly everybody, including international organizations like the CIE. Several of our important National Committees find it difficult to pay their CIE dues because of an erosion of their traditional membership base, exchange rate fluctuations and other factors....The subject of your conference, energy issues and the environmental impact of lighting are receiving our close attention at present and remain an important strategic focus."*

The message of Professor Radu MUNTEANU, Rector of the Technical University of Cluj-Napoca, emphasised the importance of light in the City and University life:

"Through time, through the competence of its builders, the City of Cluj became more and more important for science and culture, for spiritual freedom and free enterprise, and the most important decisions left in the memory of generations tell us that the contemporary scenery is a creation of the human genius perfected by request, with the appearance of nature, as the spirit of the things in the human spirit.

That is, to see, to feel, to think, to innovate, to build, and, obviously ... to light.

....

Thinking in this way, our meeting, dedicated to the ILUMINAT 2009 International Conference, is a lesson of scientific honesty, not only a problem of expression but of conception in an effort to convert a present reality for the future through a plan of intuition that mixes the field of light and shadows with the energetic and aesthetic argument.

In the framework of the Technical University of Cluj-Napoca we may be capable of scientific dialogue, learning the languages of other nations, which will change the cultural politics of mentalities and will help us become better Europeans.

This homage and scientific event reveals once again that engineering sciences to progress, because they manifest admiration for the success and they know what they owe to the past.

Professor Wout van BOMMEL - 40 years in lighting

Professor van Bommel at the retirement time. It is a nonsense to make this statement with Wout van Bommel, an ardent personality in Lighting.

Wout van Bommel was born in Tilburg, the Netherlands, 16 January 1946. He did his specialization in lighting while studying physics at the University of Technology in Eindhoven. He started as a student at Philips Lighting's lighting laboratory in March 1969 to do his Masters under the guidance of Prof de Boer and Dr. Ing. Schmidt Clausen, with the thesis "Polarized light and its use for car head lighting".

On joining Philips Lighting in 1972 he was involved in fundamental lighting application research, first under the guidance of Prof. Dr. D. Fischer. From 1974 as the manager of the outdoor engineering group of Philips' international "Lighting Design and Application Centre" (LiDAC), he set up lighting education courses for internal and external Philips Lighting international parties, later named "the Philips Lighting Academy". In 1980 he became responsible for the combined indoor and outdoor engineering group of the same Centre. In1991 he got the total responsibility for Philips' international "Lighting Design and Application Centre" (LiDAC). From 1998 - 2003 he is responsible for the company's "lighting application knowledge centre" (LiDAC Central). The department responsible for lighting application research, product development support and lighting design of large international lighting projects.

Van Bommel has carried out research into many different road lighting, sports lighting and indoor lighting subjects. Some of the concepts he proposed on the basis of his research are now used in international and national guides and standards for lighting, thus meaning that many lighting installations all over the world are being designed and commissioned using these concepts. Examples are: semi cylindrical illuminance for residential area lighting, glare rating GR for glare prevention in sports lighting, and the surround ratio in road lighting.

For more than 10 years Wout van Bommel has also been specialized in the new subject of non-visual biological aspects of lighting influencing in turn our health and wellbeing. He was responsible for two international expert symposia (Vienna 2004, Ottawa 2006) where medical, biological and lighting experts set the way for putting the new knowledge into practical use.

Wout van Bommel is member of the Lighting Society of the Netherlands and has been member of the Lighting Societies of North America (IES), the United Kingdom's Society of Light and Lighting (part of CIBSE) and the Institution of Lighting Engineers (ILE).

Since 1995 he has been one of CIE's Vice Presidents and for the period 2003-2007 he was the President of CIE.

Prof. van Bommel has published more than 100 papers in national and international lighting journals in different

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languages. He is the author of the book "Road Lighting" (translated in the Chinese and Polish language), a "standard" in its field. All over the world he has presented papers and given invited lectures at different Conferences. He is often invited as lecturer for lighting courses of universities, schools and for other interest groups at many different places in the world.

The above presentation was selected from his web site.

After his retirement from Philips Lighting March 1st 2009, he started his own lighting consultancy: "Wout van Bommel Lighting Consultant". He advices as an independent Lighting Consultant, lighting designers, researchers, companies municipalities and governmental bodies.

Although being retired since March of this year, he travelled around the word - Norway, Hungary, Turkey, China, Taiwan, Germany and UK to do expertises in lighting. Next year, he will present lecture in Vienna (CIE congress), will have teaching courses at Argentina (University of Tucuman), China (Fudan University of Shanghai), the Netherlands (evening courses for lighting professionals) and will be active in working groups of the Dutch ministry of the environment.

Wout van BOMMEL is a warm and kind friend, closed with the Romanian Lighting community, supporting by his personality our International Conferences in lighting ILUMINAT, Cluj-Napoca, Romania, starting with the first one, in 2001 (photo).

Here is his message at the ILUMINAT 2005 & Balkan Light conference:

"Where the lighting world has studied the visual aspects of lighting over a period of more than 500 years, we still learn interesting and important new things about the visual aspects of lighting. It is impressive to see how fast the Romanian lighting community has developed. This not only concerns areas of lighting research but also areas of innovative industrial products. ... It is sensational that only recently the medical, biological and lighting world discovered that lighting also has

important non-visual effects that directly relate to health and well-being. These new findings demonstrate that the subject of light and lighting is even more important than we thought. One of the roles of CIE, the International Commission for Illumination, is spreading the knowledge on light, lighting and image technology. In this respect "ILUMINAT 2005 & BALKANLIGHT 2005" is important because it helps spreading up-to-date information to the lighting community in Romania and in the Balkans. Being already the third BALKANLIGHT Conference, the lighting community of the Balkans is already accustomed to the high quality of these Conferences and I am sure the Cluj-Napoca Conference will prove this point again. But not only that: in the meantime Lighting Conferences in Romania have become famous outside Romania as well. I am convinced that also at this Conference, discussions between the Romanian and international participants will be of important mutual benefit."

"Happy many returns to you and a long and fruitful retirement life"

Florin POP

Dr. Florin POP or the charge of the light brigade

"When can their glory fade?
O the wild charge they made!"
The Charge of the Light Brigade – Alfred Tennyson

For everyone who knows Florin it is hard to believe that he is now 65 and he had decided to retire and remain only consultant professor at Technical University of Cluj-Napoca. We all have a memory of a very dynamic person always on the move: on the way to a teaching course, working at one of his European projects, at a conference somewhere in this world or in a discussion with his PhD students. Being a friendly person, he has excellent contacts in the

lighting community and is close to, in a pure alphabetical order, Wout van Bommel, David Carter, Luciano di Fraia, Liisa Halonen, Koichi Ikeda, Jeong Tai Kim, Mehmet Küçükdogu, Ramon San Martin Paramo, Janos Schanda, Axel Stockmar and George Zissis. All these distinguished leaders of the international lighting community are considering Florin as their friend.

Florin POP was born in February 10, 1944, in Blaj, Romania. He graduated the Technical University of Cluj-Napoca, Faculty of Electrical Engineering in 1966. Starting with 1967 he worked with the Technical University, where he covered the complete didactic hierarchy, from teaching assistant since 1967, to full university professor since 1992, as a member of the chair of Electrical Installations, Building Services specialty/faculty. Since 1994 he is a Ph.D. supervisor in Civil Engineering - Electrical Building Services.

When he started as a junior lecturer, lighting was one of the electricity applications, but 43 years later, lighting became a well established discipline. He was a lighting pioneer in Transylvania and this can be judged by his achievements: editor of the first scientific lighting review in Romania and the only one in East Europe, co-founder of Balkan-Light Society in 1999, founder and head of the Lighting Engineering Center in 2000, chairman of the International Lighting Conferences ILUMINAT - 2001, 2003, 2005, 2007 and 2009 (all held in Cluj-Napoca), promoter of international academic agreements between the Technical University of Cluj-Napoca, Romania and The Kyung Hee University, Korea (2003), Universitat Politecnica de Catalunya, Barcelona, Spain (1996), The University of Stuttgart, Lehrsthul Konstruktive Bauphysik, Germany (1994) and The University of Liverpool, United Kingdom (1993). For the next four-year term, Romania is represented in Lux Europa Board by Florin.

Florin POP is the success story of EU projects. In 1989 he knew nobody in lighting area, did not join a conference outside Romania and spoke French and a little English. After 20 years, there is a long list of European contracts, conferences and he uses English not only for daily e-mails. Thanks to him, many students, Ph.D. students and University staff have participated at European projects.

To present all the European research programs where Florin has contributed can be boring, because the list is a long one. Still we will talk about two: the first one, CME-03551-97 Tempus-Phare project *Lighting Engineering Centre – LEC – an excellence centre for consultancy and continuing education in the lighting field in direct link with the needs of the labour market"*, December 15, 1998 – March 14, 2000, coordinator Professor Florin POP, The Technical University of Cluj-Napoca, Romania, was the basis of the Lighting Engineering Center, and the second one *EnERLIn - European Efficient Residential Lighting Initiative*- 2006 - 2008, program Intelligent Energy-Europe - IEE, Grant EIE/05/I76/SI2.419666, coordinator Professor Georges ZISSIS, LAPLACE Laboratoire, Université Paul Sabatier, Toulouse, France, where Florin was involved in CFL promotion in Romania.

I leave on the final part the fact that Florin is a family man: at most of the conferences that he has participated, he travelled with his wife, Liana, and always talking with great pleasure about his family and, especially, about his two grandsons, Vlad and Marc. Here is the "big secret" of his retirement: he wants to be a sugar grandfather for them…

Florin graduated the University the same year I was born, but, during the twenty years we worked together, I never had the feeling of different generations. In the same time, he has set high standards, and it would be very difficult for me to approach them, and I hope he will keep an eye on this journal for many years to come.

Dorin

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