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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.

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Conferences and Symposiums

Information

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Vol. 8, No. 17 – Vara, 2006

Conferinţe şi simpozioane

Informaţii

LIGHT BETWEEN ARCHITECTURAL FEATURE AND ENERGY EFFICIENCY

Dr. Florin POP, Professor

This issue presents papers devoted to the architectural lighting, daylighting analysis and residential energy efficiency. It is edited with the financial support of LUXTEN LIGHTING CO.

KH Ahn and JT Kim analyse the effect of the exterior lighting of ancient Korean gates. Luminance and chromaticity distributions on the façades of the ancient gates were measured and evaluated the artistic results. A field survey using questionnaires collected subjective responses to the photographic images of the same gates, statistically analysed. The final conclusion shows that the image of the exterior lighting design consists of four factors: 'atmosphere', 'clearness', 'intimacy', and 'modelling'.

The research of **JT Kim, IH Yu and KH Ahn** evaluates the availability of the LAEL-KHU sky simulator to be applied under overcast sky condition in Korea. Scale model measurements were conducted under artificial sky condition and real sky. A 1/20 scale model of sidelight office and a 1/30 scale model of toplit space were made. The illuminances of inner of the models were measured and compared with daylight factor. The mean difference of DF under sky simulator and real sky were 7.1% in sidelight office model, and 1.7% in toplit space model.

MB Kobav and G Bizjak present the results of the last two years of research work on development of a substitutive light source for daylight calculation of the illuminance indoor, to design their own software to upgrade existing computer programs. The light source, which substitutes a window or a window opening, is described by photometric data in a standard way, using luminous intensity in C-planes. The results given by the simulation software present the contribution of daylight to indoor illuminance, and, thus, the available daylight for different seasons and skies and different times of observation is easier to estimate.

The Lighting Engineering Center of the Technical University of Cluj-Napoca, Romania is involved in two programs for promoting lighting energy efficiency and energy saving measures in residential buildings. **F Pop, D Beu and C Ciugudeanu** present some results of a questionnaires survey developed in November 2005, using feed-back reply forms concerning the usage degree of GSL and CFLs in households in Western Romania - 295 replies, namely 220 apartments (with 14 rooms) and 75 houses (with 2more than 7 rooms). The average use of CFLs is 1.91 units, from 1.67 units in apartments to 2.61 units in single-family houses.

G Zissis estimates key results of the first 6-month operation of the EnERLIn project. One of the first tasks carried-out consisted on the collection of various data concerning CFLs and energy consumption for lighting. These data will be analysed during the following months and they will be integrated in database that will be accessible via the project page. In Denmark, Dansk Energi investigations in the frame of EnERLIn show that about 30% of the Danish residential sector has zero CFL's, but reaches even though a level of ca. 5 CFLs per household in average. The second achievement during the 6-months period is the establishment of a very simple model concerning energy consumption for lighting in the residential sector. In Romania, the installed lighting power has an average value of 0.835 kW/household, still very modest comparing to western countries. The promotional campaign for the CFLs use in households is today very efficient and the number of CFL sales increases in Europe rapidly. The average observed growth rate concerning CFL numbers is the order of 13.5% per year (in the order of 11.5% in western and 17% in eastern countries). We should notice that the annual growth rate of the global lighting industry is in the order of 0.8%.

C Suvagau continues his very interesting and exhaustive column The Lighting in The New World, with the presentation of the LIGHTFAIR 2006 in Las Vegas. Aside the trade show itself, the education component was split in two: (1) a Lighting Institute on Daylighting, Controls and other important lighting topics, right before the beginning of the trade show, and (2) a series of complementary seminars during the trade show. Among many other new products, the big news in CFLs was the proliferation of a new standard base for CFL fixtures that allows bulbs and fixtures to be interchanged freely. To solve this problem, Energy Star worked with manufacturers to develop the GU24 standard. Consumers who purchase fixtures that use GU24 components will be able to change out lamps/ballasts of varying wattage and lumen output to meet their specific lighting needs. This overcomes a major obstacle for widespread use of CFLs.

PROEFFICIENCY is an Intelligent Energy Europe 2004 program to promote voluntary integrated initiatives for the most eco-energy efficient products, within different regional scenarios from the European Market. The consortium includes old, new and candidate Member States, acting to implement "pilot promoters initiatives" and "pilot consumers' projects/actions", as well as to monitor the effectiveness of initiatives and developed actions.

AN ANALYSIS ON EXTERIOR LIGHTING OF ANCIENT GATES IN KOREA

Hyun Tae AHN, Jeong Tai KIM
Kyung Hee University, Yongin, Korea

The luminance and chromaticity of illuminated surfaces were measured to evaluate the effect of the exterior lighting of ancient gates - Namdaemun, Kwangwhamun, Changanmun, Paltalmun. Luminance distributions on the façade of the ancient gates indicate that the basement, roofline, and interior walls are brightly emphasized during the night. The general distribution of chromaticity on the façade of the ancient gates shows that the color temperature and color filters of the lamps influenced the chromaticity distributions of the illuminated surfaces.
The effects of exterior lighting were evaluated by investigation of subjective responses to photographic images of ancient gates illuminated by exterior lighting. Using questionnaires, subjective responses to the photographic images were then collected. The collected questionnaires were statistically analyzed with the SPSS. The major variables that affect the 'general impression' and 'satisfaction' of the exterior lighting designs are 'grace', 'match', 'beauty', and 'elegance'. Finally, the results of factor analysis show that the image of the exterior lighting designs consists of four factors: 'atmosphere', 'clearness', 'intimacy', and 'modeling'.

Key Words: Luminance, Chromaticity, Subjective Responses, Exterior Lighting

1. Introduction

The exterior lighting of ancient gates has both artistic and cultural value. Because such buildings embody the history, culture, and atmosphere of a region, they should be harmonized with their surrounding night scenery. Recently, exterior lighting has been installed on some of Seoul's important buildings in Korea. However, careless exterior lighting designs can reduce the value of culturally important architecture and diminish the beauty of the urban environment at night. In order to bring the city to life and reveal its full significance, a proper understanding of the effects of exterior lighting is needed.

The aim of the study was to analyze the effects of the exterior lighting of ancient city gates - Namdaemun, Kwangwhamun, Changanmun, Paltalmun. In order to analyze the exterior lighting effect, luminance and chromaticity of the ancient gates' façades were measured. In addition to that, questionnaire survey was conducted to analyze the subjective to the exterior lighting of ancient gates.

2. Methods

The objects of study were four ancient gates of Korea, which represent typical Korean ancient gate structures.

The measurements of luminance and chromaticity were taken at the sidewalks nearest to the ancient gates from 8 p.m. to 12 a.m. The measuring instruments included a CS-100 chromaticity meter and an LS-100 luminance meter. The luminance and chromaticity of the illuminated surfaces of the façades of the ancient gates and the neighboring night scenery (windows, signboards, wall surfaces, and night sky) were measured. To describe the chromaticity, a CIE Chromaticity Diagram was used.

A field survey was performed on the selected ancient gates, and photograph of these buildings with exterior lighting were taken between 8 p.m. and 12 a.m. Using questionnaires, subjective responses to the photographic images were then collected from 120 students in the Department of Architectural Engineering of Kyung Hee University. From the collected questionnaires, 90 valid questionnaire sheets were selected for evaluation. The SD scale method was used as a research tool for evaluating subjective. The collected questionnaires were statistically analyzed with the SPSS. Applied statistics analysis included a profile analysis, T-test, correlation analysis, and a factor analysis.

3. Exterior Lighting of Ancient Gates

3.1 Namdaemun

The façade of Namdaemun was illuminated by floodlights, which were placed on an adjacent sidewalk. These floodlights illuminated the roof and roofline of the second floor. The brackets of second floor, illuminated by floodlights which are placed in the entrance yards. Spotlights (CDM PAR lamps) were also used to illuminate the first floor's brackets from underneath (Table 1).

Table 1 Luminaire of Namdaemun

lluminated parts	Lamps (w)	Locations	Quantity
Roof	MH/1,000	Sidewalk	16
Brackets(2nd fl.)	MH/1,000	Entrance	12
Brackets(1st fl.)	CDM/ 38,70	Inside wall	134
Basement	MH /250	Front yard	28
Trees	CDM/38, 70	Front yard	8

The measurements show that the luminance of the basement is the brightest (6.4 cd/m^2). In descending order of brightness, other measurements were as follows: the center part of the second floor roofline (3.7 cd/m^2), the right part of the second floor roofline (3.3 cd/m^2), the left part of the first floor roofline (2.9 cd/m^2), the upper right part of the basement (2.5 cd/m^2), and the surface of the second floor roof (0.7 cd/m^2). The general distribution of luminance shows that the plane design elements of the bottom part of Namdaemun are emphasized with brighter exterior lighting than are the linear elements of the upper parts (second floor brackets, roof, and roofline). The colors of Namdaemun's façade were yellow (first floor brackets), green (second floor brackets), brown (basement), black (roof tiles), white (rooflines). The general chromaticity distribution belongs to the yellow color range of the chromaticity diagram. This result shows that the color of the roof, brackets, and the roofline do not affect the chromaticity distribution, except for the color of the first floor brackets. Therefore, it may be assumed that the color filter and color temperature of the lamps did affect the chromaticity distribution.

Figure 1 Luminance of Namdaemun's façade

Table 2 Luminance & Chromaticity (A~B3)

	A	B1	B2	B3
Luminance (cd/m²)	3.7	0.7	3.3	2.9
Chromaticity	X=3924 Y=3915	X=3950 Y=3787	X=3908 Y=3700	X=392 Y=3915

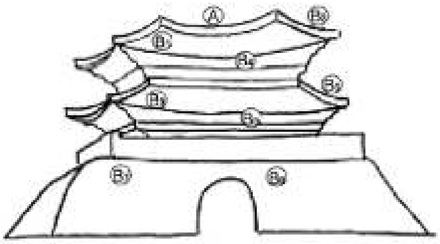


Figure 2 Measuring points

Table 3 Luminance & Chromaticity (B4 ~B8)

	B4	B5	B6	B7	B8
Luminance (cd/m²)	1.4	5.4	2.2	6.4	2.5
Chroma ticity	X=3907 Y=4064	X=4266 Y=4269	X=3857 Y=3732	X=392 Y=407	X=4072 Y=4102

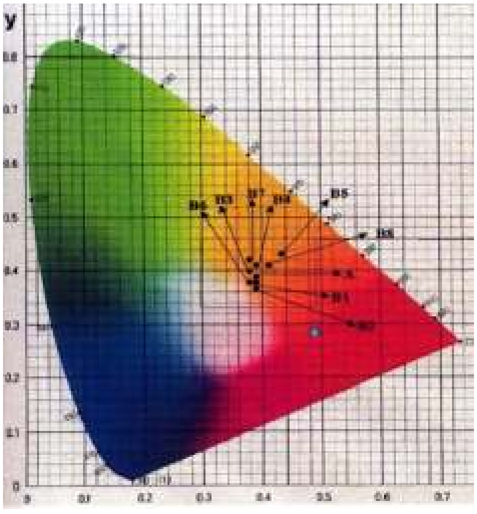


Figure 3 Chromaticity diagram

3.2 Kwanghwamun

The façade of Kwanghwamun was illuminated by floodlight, placed on the sidewalks across the street. These floodlights illuminated the basement, roofline, and roof. The brackets of the first and second floor were illuminated by ramps set under the brackets. Lamps placed under the sidewalls of Kwanghwamun also illuminated those walls (Table 4).

Table 4 Luminaire of Kwanghwamun

Illuminated parts	Lamps (w)	Locations	Quantity
Roof	MH / 1,000	Sidewalk	4
Brackets	CDM – TD 70	Sidewall	6
Basement	MH 1,000 W	Sidewalk	47
Sidewall	SDW – T 100	Side wall	14
Entrance	SDW – T 50	Entrance	8

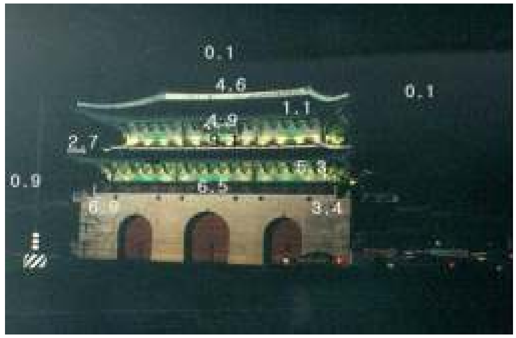


Figure 4 Luminance of Kwanghwamun's façade

The results show that the center part of the first floor roofline is the brightest (9.1 cd/m^2). In descending order of brightness, other measurements are as follows: the left part of the basement (6.9 cd/m^2), the center part of the first floor brackets (6.5 cd/m^2), the right part of the first floor brackets (5.3 cd/m^2), the center part of the second floor brackets (4.9 cd/m^2), the center part of the second floor roofline (4.6 cd/m^2), the right part of the basement (3.4 cd/m^2), the left part of the first floor roofline (2.7 cd/m^2), and the right part of the second floor roof (1.1 cd /m^2).

The luminance distribution of Kwanghwamun shows that the brackets are emphasized with up-lighting, which enhances the colored wall. It also indicates that the upper part of Kwanghwamun is brighter than the plane elements in the basement. This exterior lighting effect is clearly visualized due to the dark background, which highlights the carving in the traditional Korean architecture.

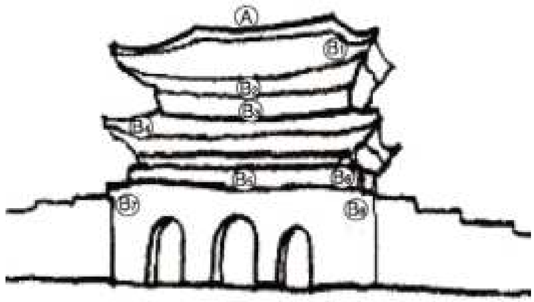


Figure 5 Measuring points

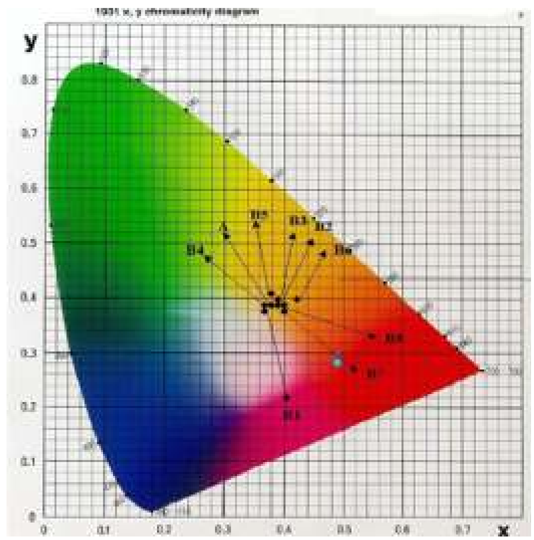


Figure 6 Chromaticity diagram

The colors of the façade of Kwanghwamun were white rooflines black (roof-tiles), green (first and second floor bracket) and brown (basement). The general chromaticity distributions belong to the yellow color image of the chromaticity diagram. The results indicate that the color of the wall under the brackets is matched with the chromaticity. It may be inferred that the yellow filters and color temperature of the lamps influenced the chromaticity distribution of the façade of Kwanghwamun.

Table 5 Luminance & Chromaticity (A~B3)

	A	B1	B2	B3
Luminance (cd/m²)	4.6	1.1	4.9	9.1
Chromaticity	X=3 800 Y=3870	X=3747 Y=3818	X=3818, Y=3861	X=3892 Y=3960

Table 6 Luminance & Chromaticity(B4 ~B8)

	B4	B5	B6	B7	B8
Luminance (cd/m²)	2.7	6.5	5.3	6.9	3.4
Chroma ticity	X=3370 Y=3812	X=3828 Y=4069	X=4282 Y=3976	X=391 Y=378	X=3964 Y=3827

3.3 Changanmun

Changanmun was illuminated by floodlight, placed in the adjacent walkway. These floodlights illuminated the roof of the second floor and the brackets of the façade. Lamps set along the bottom of the external walls illuminated those walls, and lamps placed inside the walls illuminated the basement and brackets of Changanmun (Table 7).

Table 7 Luminaire of Changanmun

Illuminated parts	**Lamps (w)**	**Locations**	**Quantity**
Roof	MH/1,000	Sidewalk	2
Brackets	MH/150	Interior yard	21
Outside wall	Hallogen 500	Outside wall	10
Inside wall	Hallogen 500	Inside wall	4
Entrance	Hallogen 300	Floor	2

The results show that the interior wall of the entrance is the brightest (7.4 cd/m^2). In descending order of brightness, other measurements are as follows: the right part of the castle wall (3.2 cd/m^2), the right part of the first floor bracket (3.0 cd/m^2), and the left part of the second floor bracket (1.8 cd/m^2). Thus, the exterior lighting of the façade of Changanmun is characterized by the illumination of the interior and exterior wall. The general distribution of luminance shows that the curved elements (entrance arch and castle wall) are emphasized with lighting. And the brackets of the second floor reveal the modeling effect caused by floodlighting from the left side of the façade, which resulted in brightness variation.

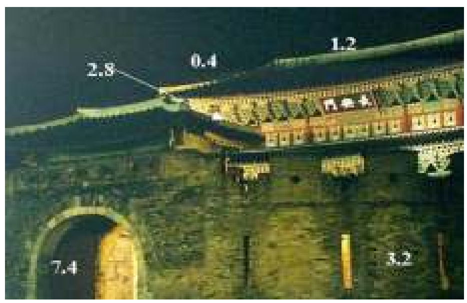


Figure 7 Luminance of Changanmun's façade

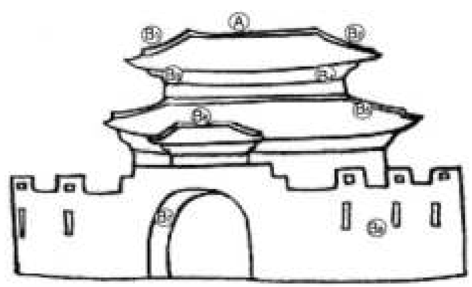


Figure 8 Measuring points

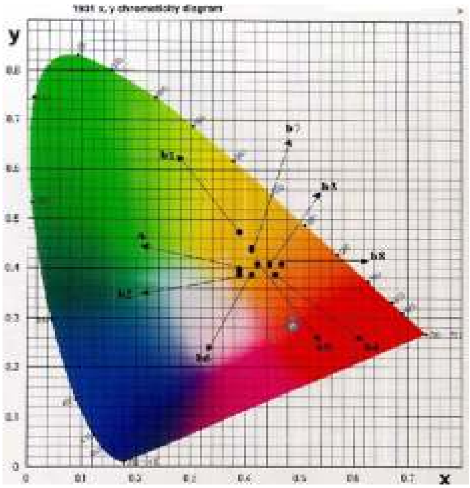


Figure 9 Chromaticity diagram

The colors of the facade of Changanmun were white (roof line), black (roof), yellow (brackets, interior and exterior of the castle wall). The measurement of chromaticity shows that the general distributions of chromaticity belong to the yellow color range of the chromaticity diagram. This indicates that the major exterior lighting color is in accordance with the chromaticity distributions (yellow), except for the chromaticity of the roof and roofline. Therefore, the lighting color of the lamps may have also affected the chromaticity distribution.

Table 8 Luminance & Chromaticity (A~B3)

	A	B1	B2	B3
Luminance (cd/m²)	1.2	0.4	2.7	2.8
Chromaticity	X=3985 Y=3991	X=3904 Y=4651	X=3809 Y=3872	X=4466 Y=4109

Table 9 Luminance & Chromaticity (B4~B8)

	B4	B5	B6	B7	B8
Luminance (cd/m²)	1.8	3.0	1.8	7.4	3.2
Chroma ticity	X=4473 Y=3946	X=4299 Y=4071	X=4108 Y=3956	X=403 Y=420	X=4625 Y=4161

3.4 Paltalmun

Floodlights placed on nearby roads illuminated the roof and brackets of the second floor of Paltalmun. The exterior walls were illuminated by halogen ramps. Floodlights installed on poles inside the surrounding yard illuminated the basements, brackets, and roof of the first floor of Paltalmun (Table 10) [3].

Table 10 Luminaire of Paltalmun

lluminated parts	Lamps (w)	Locations	Quantity
Roof	MH/1,000,150	Side walk	2
Brackets	MH/150	Interior yard	14
Outside wall	Hallogen 500	Outside wall	10
Inside wall	Hallogen 300	Inside wall	4
Entrance	Hallogen 300	Floor	2

The results show that the luminance of the right part of the roofline of the first floor is brightest (3.7 cd/m^2). In descending order of brightness, other luminance measurements are as follows: the interior wall of the entrance (3.6 cd/m^2), the left part of the first floor roofline (2.5 cd/m^2), the right part of the second floor bracket (2.3 cd/m^2), the center part of the second floor bracket (1.6 cd/m^2), and the right part of the second floor roof (0.1 cd/m^2).

Figure 10 Luminance of Paltalmun's façade

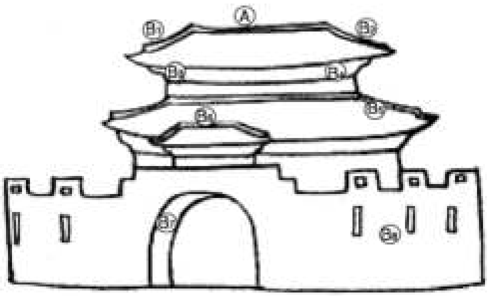


Figure11 Measuring points

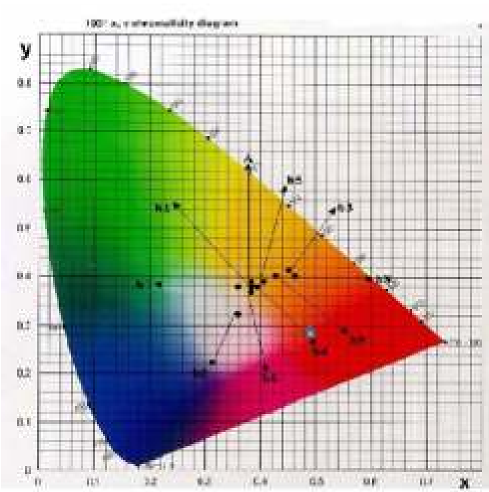


Figure 12 Chromaticity diagram

Thus, the exterior lighting of Paltalmun's façade is characterized by the accenting of linear elements (roofline) as well as curved and plane elements (interior wall of entrance arch). The colors of the façade of Paltalmun were yellow (interior wall of entrance arch), white (roofline), black (roof), and dark brown (outside wall). The measurements reveal that the general distributions of chromaticity belong to the yellow color range of the chromaticity diagram, except for the chromaticity of the right part of the roof of the second floor (white). It mat be inferred, therefore, that the chromaticity of the other architectural parts were affected by the lighting colors and temperature of the lamp.

Table 11 Luminance & Chromaticity (A~B3)

	A	B1	B2	B3
Luminance (cd/m²)	3.5	1.6	0.1`	2.1
Chromaticity	X=3922, Y=3948	X=3909 Y=3868	X=3761 Y=3340	X=4057 Y=3861

Table 12 Luminance & Chromaticity (B4~B8)

	B4	B5	B6	B7	B8
Luminance (cd/m²)	2.3	3.7	1.6	3.6	1.3
Chroma ticity	X=3994 Y=3831	X=3851 Y=3711	X=4434 Y=4141	X=431 Y=401	X=4402 Y=4034

4. Subjective responses on the exterior lighting of ancient gates

4.1 Descriptive statistics

The subjects (of the 90 valid questionnaires) were classified into four age groups. Twenty-one subjects (23.3%) were between the ages of 20 and 21. Twenty-two subjects (24.4%) were between the ages of 22 and 23. Forty-two subjects (46.7%) were between the ages of 24 and 25. And five subjects (5.6%) were over 26 years old. Sixty-seven subjects (74.4%) were male and 23 subjects (25.6%) were female. The number of subjects who had seen the objects of study before completing the questionnaire was as follows: 48 subjects (53.3%) had seen Namdaemun; 34 subjects (37.8%) had seen Kwanghwamun; 30 subjects (33.3%) had seen Changanmun; and 37 subjects (41.1%) had seen Paltalmun.

4.2 Profile analysis of the subjective responses

As to the six questions concerning the 'atmosphere' of the lighting designs, subjects generally showed positive responses. In particular, all questions about the exterior lighting of Kwanghwamun received positive answers.

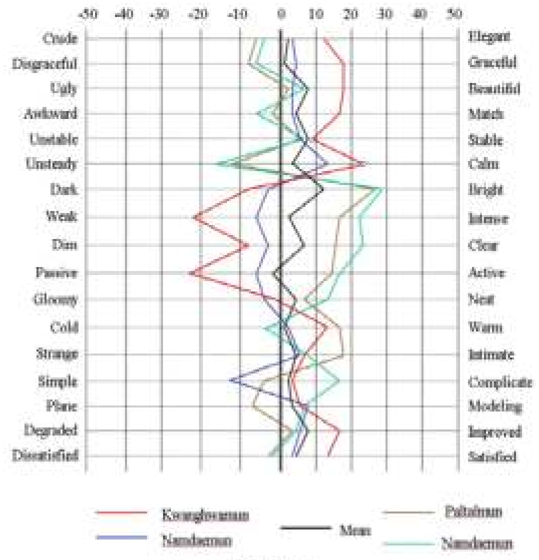
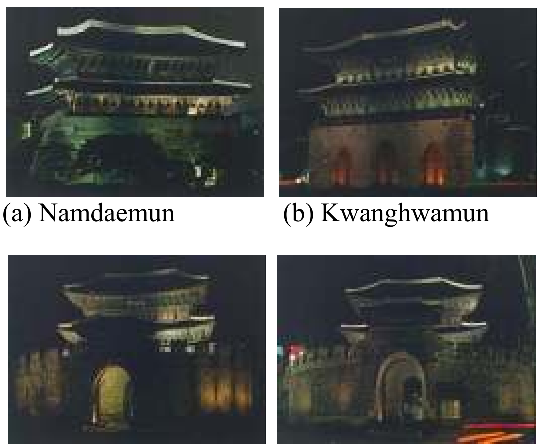


Figure 14 Profile analysis



(a) Namdaemun (b) Kwanghwamun

(c) Changanmun (d) Paltalmun

Figure 13 Photographic images of ancient gates at night

Concerning five questions about the 'clearness', the exterior lighting of Namdaemun was regarded as the brightest and clearest. Paltalmun was regarded as having the second clearest lighting design. Kwanghwamun, which was considered as having the best 'atmosphere', was also regarded as having the 'darkest' lighting design. This implies that 'atmosphere' and 'clearness' of exterior lighting are contrary features. Concerning the two questions of the 'intimacy' of the exterior lighting, subjects thought that the buildings were expressing a 'warm feeling' and 'intimate feeling'.

Changanmun, which was illuminated with general lighting instead of spot lighting, received the most positive responses to the two questions concerning the 'modelling' of the lighting effect.

As to the questions concerning the change of image due to exterior lighting, subjects thought that the images of each the buildings were improved. In particular, Kwanghwamun's image was regarded as having been improved the most. Subjects were satisfied with the exterior lighting of Kwangwhamun and Changanmun, but not with Namdaemun and Paltalmun.

4.3 Images of the ancient gates

T-tests were used to determine the differences between the images of each of the ancient gates. It was found that there are valid differences for each of the variables, except the variables 'stable' and 'intimate'. A correlation analysis was performed to select the major variables that affect the image and level of satisfaction. The major variables that affect the 'general impression' of the exterior lighting designs are 'grace (0.671)', 'match (0.638)', 'elegance (0.542)', and 'beauty (0.523)', in that order. The major variables that affect the 'satisfaction' of the exterior lighting designs are 'grace (0.752)', 'match (0.708)', 'beauty (0.617)', and 'elegance (0.609)', in that order. These results show that the variables that affect the 'general impression' of the exterior lighting designs are very similar to those that affect the 'satisfaction' of the exterior lighting designs. Among these variables, 'grace' and 'match' are the most important. Also, the variables related to the 'intensity of light' are contrary to the lighting effect.

Table 13 Factor analysis on the exterior lighting effect of ancient gates

Factors	Variables	Factors F1	F2	F3	F4	Communalities
F 1 (Atmosphere)	Elegant – Crude	0.83	−.128	.100	0.02	.727
	Graceful – Disgraceful	0.83	−.225	5E-02	.127	.762
	Beautiful – Ugly	0.81	.106	.113	.127	.708
	Match – Awkward	0.76	−.129	.158	0.09	.629
	Stable- Unstable	0.59	.139	.398	−.119	.546
	Calm - Unsteady	0.58	−.547	0.05	−0.04	.654
F2 (Clearness)	Bright – Dark	−0.06	.798	0.09	−0.04	.652
	Intense – Weak	−0.30	.772	−0.08	−0.01	.699
	Clear – Dim	0.16	.743	−0.08	.119	.599
	Active - Passive	−0.27	.674	.141	.126	.563
	Neat - Gloomy	0.48	.645	0.03	.181	.687
F3 (Intimacy)	Warm – Cold	0.06	−.108	.843	0.11	.740
	Intimate - Strange	0.33	.171	.698	−0.08	.634
F4 (Modelling)	Complicate – Simple	−0.04	.221	−.167	.765	.660
	Modelling - Plane	0.24	−0.07	.233	.742	.663
Eigenvalues		4.49	3.11	1.26	1.05	
Valid percent		29.9	20.7	8.3	7.0	
Cumulative percent		29.9	50.7	59.0	66.0	

4.4 Factors of the exterior lighting images

A factor analysis was performed to select the major factor that determines the images of the ancient gates illuminated by exterior lighting. From the anlysis, four factors were selected: 'atmosphere', 'clearness', 'intimacy', and 'modeling'. The variables that explain 'atmosphere' are 'graceful', 'match', 'beautiful', 'elegant', 'stable', and 'calm'. The factor of 'clearness' consists of 'bright', 'intense', 'clear', 'active', and 'neat'. The variables that belong to the factor 'intimacy' are 'visually warm' and 'intimate'. Finally, 'modeling' consists of the variables 'visually complicated' and 'modeling'. Using the selected the factors, about 66% of the effect of the exterior lighting designs could be explained (Table 13).

5. Conclusions

Luminance distributions on the façade of the ancient gates indicate that the basement, roofline, and interior walls are brightly emphasized during the night. The general distribution of chromaticity on the façade of the ancient gates is yellow.

Therefore, it may be assumed that the color temperature and color filters of the lamps influenced the chromaticity distributions of the illuminated surface.

Subjective responses to the atmosphere of the exterior lighting designs were positive. Kwanghwamun, in particular, received a positive response. Concerning the 'clearness' of the exterior lighting designs, Namdaemun was judged to be the brightest and clearest. The major variables that affect the 'general impression' and 'satisfaction' of the exterior lighting designs are 'grace', 'match', 'beauty', and 'elegance'. Finally, the results of factor analysis show that the image of the exterior lighting designs consists of four factors: 'atmosphere', 'clearness', 'intimacy', and 'modeling'.

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COMPARATIVE DAYLIGHTING PERFORMANCE ANALYSIS OF REAL SKY AND SKY SIMULATOR BY SCALE MODEL EXPERIMENTS

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Scale model measurements have been conducted to identify the differences of daylighting performance under real sky and in sky simulator developed by LAEL of KHU. Under overcast sky condition, two kinds of scale model experiments were conducted by using Agilent data logger and photometric sensor Li-cor. Firstly, a 1/20 scale model of an office room with 4.9 m width, 7.2 m length, and 2.6 m height was made. Five measurement points were set at 1.2 m, 2.4 m, 3.6 m, 4.8 m, and 6.0 m from the window. During measurement, the luminance of zenith and horizon in a sky simulator was 2550 cd/m² and 851 cd/m². The luminance of zenith and horizon in real overcast sky was 11,479 cd/m² and 3283 cd/m². The mean of the measurements between sky simulator and real sky was 7.1% of difference. Secondly, a 1/30 scale model of toplit space with 15 m width, 15 m length, 15 m height was made. The measurement point was set at center of the atrium floor and the well index of the model was set in 0.25, 0.5, 0.75, 1.0, 1.25. During measurements, the luminance of zenith and horizon in a sky simulator was 2550 cd/m² and 851 cd/m². The luminance of zenith and horizon in real sky was 6737 cd/m² and 2643 cd/m². The mean of the measurements between sky simulator and real sky was 1.7% of difference. It is proved that the LAEL sky simulator is fully validated for accuracy and validation for daylighting researches.

Keywords: sky simulator, artificial sky, CIE standard overcast sky, scale model

1. Introduction

Maintaining constant sky condition is very important during the daylighting experiment. Sky simulator can represent a consistent sky condition to study daylighting performance in scale model measurement.

LAEL (Light and Architectural Environment National Laboratory) of Kyung Hee University (KHU) has developed a 6-meter diameter sky simulator that is hemispherical skydome type. It represents a standard sky condition illuminated by light source mounted in a circular. The sky simulator of KHU was verified reproducing the CIE standard overcast sky by measurement of luminance of its sky surface [2].

This research evaluated the availability of the sky simulator under overcast sky condition in Korea. For the purpose, scale model measurements were conducted under artificial sky condition and real sky. A 1/20 scale model of sidelight office and a 1/30 scale model of toplit space were made. The illuminances of inner of the models were measured and compared with daylight factor.

2. Sky Simulator at LAEL

2.1 Configuration

The dimensions of LAEL sky simulator is 6m-diameter and 3.7 m-height. Interior surface was painted white matte finish that possible reproduce overcast sky condition by distributing light uniformly. The hemispherical shell was consisted of 145 insulated steel-skinned parts and the radius of curvature of each part was calculated in order to the shape of sky simulator has completely curved surface.

The data of scale model experiment was acquired by illuminance measurement equipment of Li-cor and data logger of HP. A table to support daylighting model was equipped that can be controlled height.

Figure 1 Outdoor and indoor of sky simulator

2.2 Lighting and Control System

Halogen lamps, consumption is 500 W and luminous flux is 9500 lm were installed 3 rows and 24 lines on the edge of horizontal of inner dome. With all lamps on, maximum horizontal illuminance was about 7020 lx and sky zenith lluminance was about 3400 cd/m². The angle of light source was each individually controlled that possible

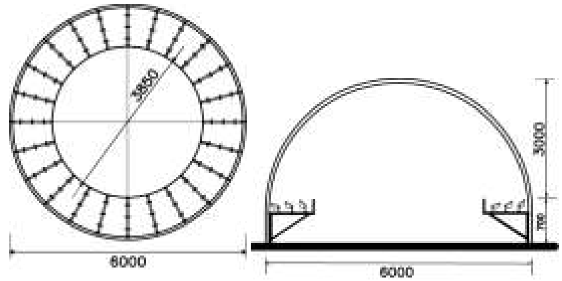

Figure 2 Configuration of sky simulator

reproduce various sky condition. And the brightness of luminaire also each individually controlled by dimmer and suitable sky condition for the purpose of experiment can be represented.

The heated atmosphere by 72 halogen lamps was handled 2 air conditioners and ventilating opening connected outside through round shape flexible duct.

3. Scale Model Experiments

3.1 Monitoring System

The measurement and data acquisition system were configured based on the IEA SHC Task 21 monitoring system. The measurement system included photometers of Li-cor and millivolt adaptor, which converts mA into mV. The data acquisition system was composed with Agillent's terminator, a data logger and a PC. The prepared monitoring system was controlled with Agillent's 4.1program.

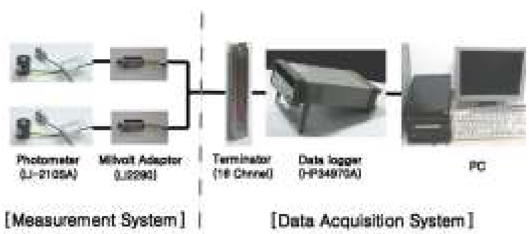

Figure 3 Monitoring sistem

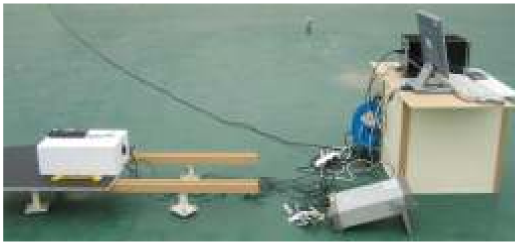

Figure 4 View of monitoring system

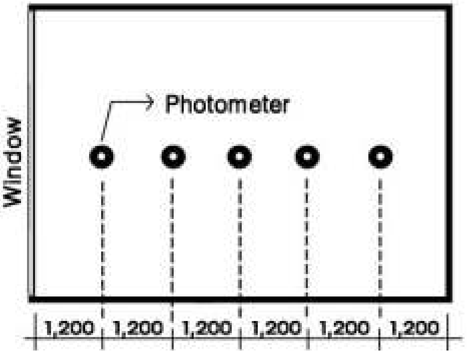

Figure 6 Location of measurement points in sidelight scale model

3.2 Scale Model of a Sidelight Office

For measurement of daylight illuminance, sidelight scale model was made, typical office space. The space was composed of a configuration of 4.9 m width, 7.2 m length, and 2.6 m height, adopting side lighting through a window sized 4.8 m (width) by 1.7 m (height).

The scale model was made in 1/20 scale in consideration of the dimension of sky simulator and the size of photometer and facility of measurement.

The scale model was consisted of form board, reflect light in a diffuse pattern and easy to handle.

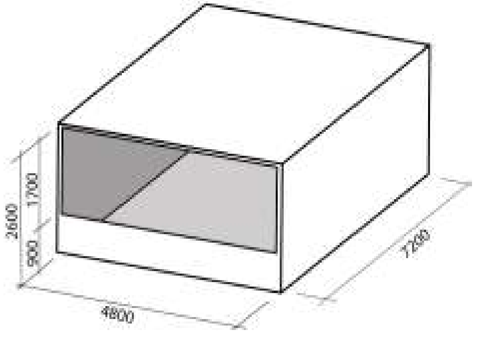

Figure 5 Configuration of sidelight scale model

Under overcast sky in sky simulator and real sky, the illuminance was measured and compared. Measurement of illuminance was carried out by setting the work plane height at 0.85 m perpendicular to the window. 5 measurement points were set at 1.2 m, 2.4 m, 3.6 m, 4.8 m, 6.0 m, respectively, from the window. Exterior horizontal illuminance was measured simultaneously under real sky. To verify the accuracy of Li-cor photometer, TOPCON IM-5 was used to measure exterior horizontal illuminance and compared with value of Li-cor.

The experiment of scale model in sky simulator was carried out on November 9, 2005, 10-second intervals for 2-minutes. Prior to carrying out the measurement, luminance distribution of interior surface of dome was set to CIE standard overcast sky model with all lamps on. The zenith luminance was 2550 cd/m² and horizontal luminance was 851 cd/m². The error rate of Li-cor photometer and TOPCON IM-5 was below 0.1%.

(a) measurement system (b) scale model

Figure 7 Measurement of illuminance

Under real overcast sky, the scale model measurement was carried out from 12:00 to 12:30 on November 13, 2005, 10-second intervals for 2-minutes. The scale model was installed on the rooftop of a building in KHU that has no obstruction. According to Korea Meteorological Administration, cloud cover was 7.1, nearly overcast sky. The measurement model was set to face to 4 direction, east, west, south and north. The main window faces to south. The mean zenith luminance was 11,479 cd/m² and the mean horizontal luminance was 3283 cd/m² during the experiments.

(a) View of Measurement (b) View of scale model

Figure 8 Measurement of illuminance in real sky

Due to the difference between sky condition of sky simulator and real overcast sky, the acquired illuminance was converted to daylight factor and compared. The DF Values within the artificial sky are quite similar to that of real overcast, mean difference of the two skies condition was 7.1%. The little difference of DF value was caused by daylight, the cloud cover was 7.1.

3.3 Scale Model of a Toplit Space

Another type of evaluation model was 1/30 scale model of a toplit space, with 15m width, 15 m length, 15 m height. The material of scale model was paper and wood, reflect light uniformly. The measurement point of interior horizontal illuminance was set at center of the atrium floor and the well index of the model was set in 0.25, 0.5, 0.75, 1.0, 1.25. Both exterior horizontal illuminance and interior horizontal illuminance were measured simultaneously under real overcast sky.

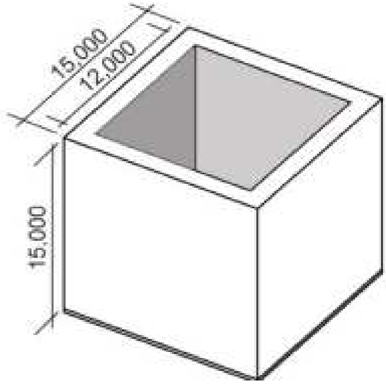

Figure 9 Configuration and measurement of toplit space model

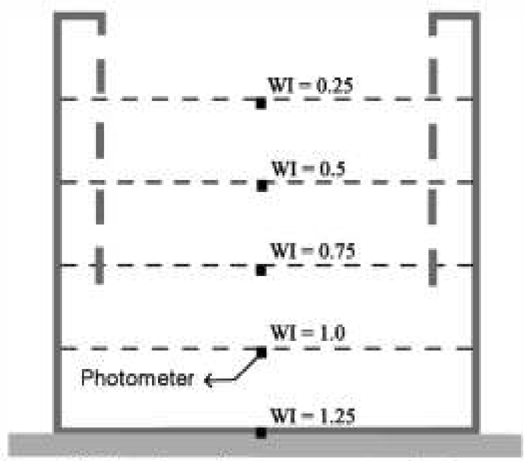

Figure 10 Location of measurement points in toplit space model

Figure 11 View of toplit space model measurement

The illuminance in sky simulator was conducted on February 16, 2006, 10-second intervals for 2-minutes. With all lamps on, luminance distribution of interior surface of sky simulator was set to CIE overcast sky by controlling the brightness and angle of the lamps. The zenith luminance was 2550 cd/m² and horizontal luminance was 851 cd/m².

Figure 12 View of measurement in sky simulator

The measurement of daylight illuminance under real overcast sky was carried out from 14:00 to 14:50 on March 20, 2006. The scale model of toplit space was set on the rooftop of a building in KHU. Under overcast sky, cloud cover was 10, illuminance was measured by 10-second for 2-minutes each well index. The mean zenith luminance was 6737 cd/m² and mean horizontal luminance was 2643 cd/m².

Table II and Figure 16 show the illuminance and DF of toplit space model of the sky simulator and real overcast sky. Sky condition of the two space were different, exterior horizontal illuminance was 4573 lx within sky simulator and 19,798 lx under real overcast sky. However the daylight factor value, relative value of interior and exterior was nearly equal, the difference of the mean was 1.7% regardless of well index.

Figure 13 View of measurement in real sky

Table I Illuminance and daylight factor of sidelight office model

			Exterior Illuminance	Interior Illuminance				
				1.2m	2.4m	3.6m	4.8m	6.0m
Sky Simulator		Illuminance (lx)	5,080	1,363	999	877	766	738
		DF (%)	.	26.8	19.7	17.2	15.1	14.5
Real Sky	South	Illuminance (lx)	27,555	8,537	5,766	4,777	4,129	3,846
		DF (%)	.	31.0	20.9	17.3	15.0	14.0
	West	Illuminance (lx)	20,207	5,847	4,119	3,647	3,010	2,837
		DF (%)	.	28.9	20.4	17.2	14.9	14.0
	North	Illuminance (lx)	21,913	5,487	3,788	3,197	2,837	2,699
		DF (%)	.	25.0	17.1	14.6	12.9	12.3
	East	Illuminance (lx)	26,946	6,542	4,436	3,712	3,260	3,115
		DF (%)	.	24.3	16.5	13.8	12.1	11.6

Table II Illuminance and daylight factor of toplit space model

Well Index		1.25	1.0	0.75	0.5	0.25
Sky Simulator	Interior Illuminance (lx)	1,387	1,973	2,539	3,334	4,370
	Exterior Illuminance (lx)	4,414	4,496	4,561	4,643	4,749
	DF (%)	31.4	43.9	55.7	71.8	92.0
Real Sky	Interior Illuminance (lx)	7,372	9,374	10,962	13,035	15,094
	Exterior Illuminance (lx)	23,803	21,766	19,133	17,685	16,425
	DF (%)	31.0	43.1	57.3	73.7	91.9

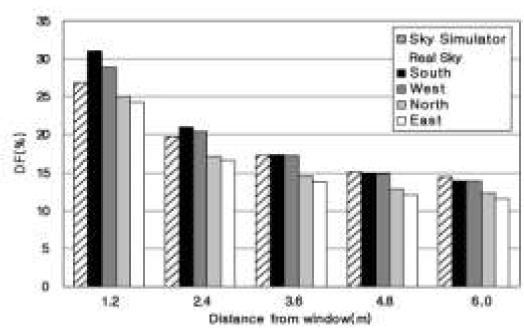

Figure 14 Distribution of daylight factor of sidelight office model

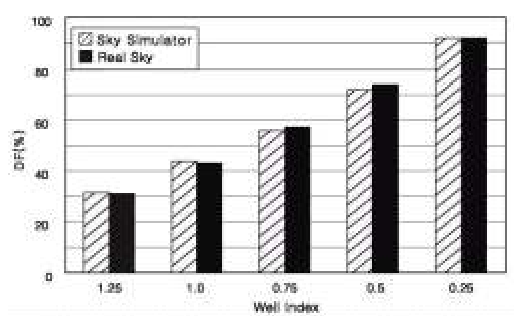

Figure 15 Distribution of daylight factor of toplit space model

4. Conclusions

This paper evaluated the availability of the sky simulator by comparing daylight factor under sky simulator and real overcast sky. For the purpose two kind of scale model measurement, sidelight office and toplit space, were conducted. The measurement result of the sky simulator and real overcast sky are as follows. In sidelight office model, the illuminance of five points was measured under partly overcast sky. The mean difference of DF under sky simulator and real sky were 7.1%. In toplit space model, the center of the floor was measured by 5 well indexes under overcast sky. The DF of two spaces were nearly same, mean difference was 1.7%.

As a result of two type of scale model measurement, the developed sky simulator was verified for its availability as a daylight evaluation facility, by showing the gradient of daylight factor as almost the same. The sky simulator can be applied to evaluate daylighting performance under overcast sky.

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INDOOR DAYLIGHT CALCULATIONS WITH DEVELOPED SUBSTITUTIVE LIGHT SOURCE

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The central focus of the paper is to present the results of the last two years of research work on development of a substitutive light source for daylight calculation of the illuminance indoors. In the paper, calculation of spatial distribution of daylight according to the new CIE standard CIE S 011/E 2003: Spatial Distribution of Daylight – CIE Standard General Sky is discussed and used to calculate photometric data of a light source which substitutes a window or a window opening in computer calculations. With use of this photometric data which can be imported into calculation software, this software becomes more useful.

1. Introduction

In the beginning of 2003 CIE adopted a new standard: CIE S 011/E 2003: Spatial Distribution of Daylight – CIE Standard General Sky, which defines spatial luminance of a sky vault. The new standard makes it possible to calculate indoor illuminance caused by the sky in a standardised manner.

Lighting designers and designers of low voltage electric installations in buildings are using many different computer programmes to evaluate lighting design and to calculate illuminance. Most of the software is designed to calculate illuminance caused by artificial light sources only and are not capable of taking daylight into account. This is the reason why we decided we need to design a computer programme that would upgrade existing software. Such improved software could calculate contribution of daylight in indoor illuminance in line with the new CIE standard. By using the new software we can perform calculations of spatial distribution of sky luminance. The calculation takes into account location and time of observation, and the type of sky, which is also defined with the new CIE standard.

Using the calculated spatial luminance distribution we obtain photometric data for a light source which substitutes a window or a window opening in a room for which daylight illuminance is to be determined. Photometric data is calculated and written down in a standard way, using luminous intensity in C-planes. The output of the computer programme is an .IES file that contains all photometric data for a substitutive light source. The configuration of the output file is the same as is with other luminaries. Using identical format makes it possible to import window photometric data file into most of the existing computer programmes, and by doing so it is possible to calculate daylight illuminance indoors.

2. Calculation of luminance distribution

The calculation of spatial luminance distribution is based on the new CIE standard S 011/E:2003. On the basis of this standard we have designed a computer programme, which consists of three modules. The first two modules of the developed programme are designed to calculate luminance distribution. With the first module, module Sun (user interface shown in Figure 1), the position of the Sun is calculated. It is defined with the angle of elevation above the horizon and with azimuth.

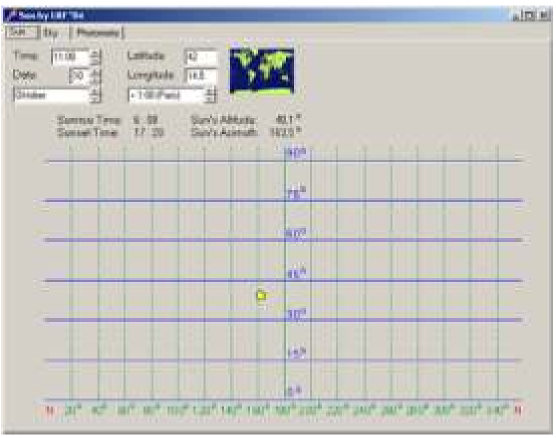

Figure 1 User interface of module Sun

Both data are calculated with regard to the geographical position of the observer, and date and time of observation.

The second module, Sky, calculates spatial sky luminance. The distribution depends on the position of the Sun, which is calculated with module Sun, and on the type of sky. The latter is chosen in module Sky from a CIE standard scale. The results of the calculations are presented graphically by means of shading as shown in Figure 2.

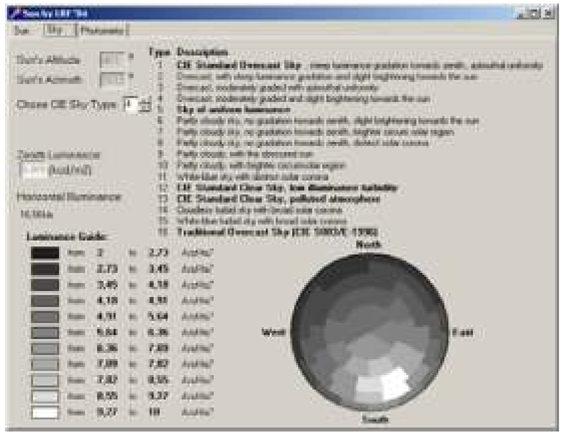

Figure 2 User interface of module Sky

An adaptive scale with a constant number of steps is used to graphically represent the absolute sky luminance. Sky patches are shaded according to the luminance. The brightest sky patch is shaded white and the darkest patch is coloured black. All other sky patches have different shades of grey chosen from the interval between white and black.

The reason why we use the adaptive scale lies in a great difference in luminance between the darkest sky patch at dark sky (low angle of elevation of the Sun, overcast sky) and the brightest sky patch at bright sky (high angle of elevation of the Sun, clear sky).

3. Photometric data for substitutive light source

For photometric description of a substitutive light source we chose C-planes with luminous intensity. A light source that substitutes a window or a window opening has in general a completely asymmetrical geometry of luminous intensity. Therefore it is important to describe photometric data in as many C-planes as possible. We decided to use 7 C-planes (0^0, 10^0, 45^0, 90^0, 135^0, 170^0, 180^0) and 19 vertical angles on each C-plane, which gave us a total of 133 directions. As a result, the light source, which substitutes a window or a window opening, will be described with 133 luminous intensities (shown on Figure 3.). Another C-plane (C-plane 360^0) is used only to define symmetry of light source in IES file for software calculation purposes.

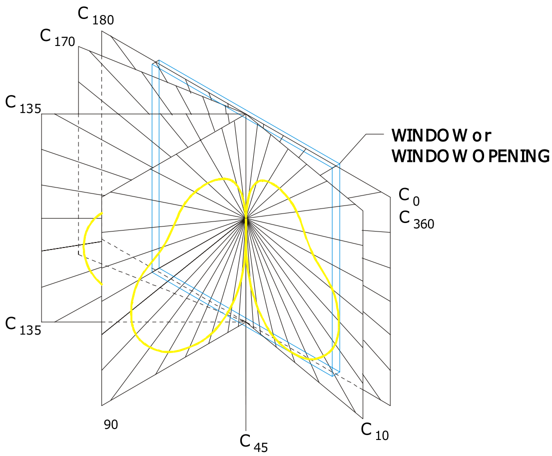

Figure 3 Polar diagram of a substitutive light source

4. Photometric curve of a substitutive light source

Light, emitted form the sky dome, comes to the point of observation in a room in three different ways (shown on Figure 4). Each way contributes its own component of light.

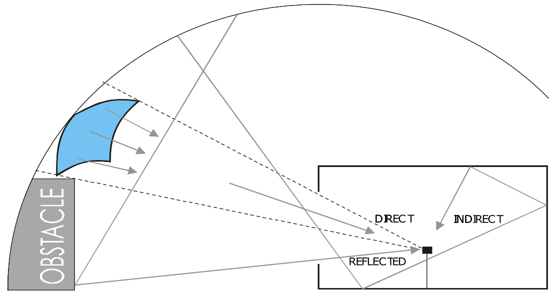

Figure 4 Three components of light coming to a point

The first light component is a direct radiation of a sky patch on the point of observation. This component is called "Direct". The second component is the reflection of light emitted from a sky patch, reflected from outdoor objects and outdoor ground. This component is called "Reflected". The last component is called "Indirect" and comes from the sky dome directly into the room or is reflected from outdoor objects or ground but hits the point of observation only after it has reflected from walls of the room.

The calculation of a direct component is based on the simplified presupposition that the window or the window opening is in the centre of a sphere. The upper hemisphere represents the sky and the lower hemisphere represents the outdoor objects and outdoor ground.

Taking into account the fact that the window is in the centre of a sphere and that the sky is above the window, it can be assumed that the sky has direct influence only on luminous intensities in vertical angles from 0^0 to 90^0. The light reflected from outdoor ground is the only influence on vertical angles from 90^0 to 180^0, as we do not take into account any outdoor objects. Figure 5 shows influence of a certain light component on photometric curve of a window or a window opening.

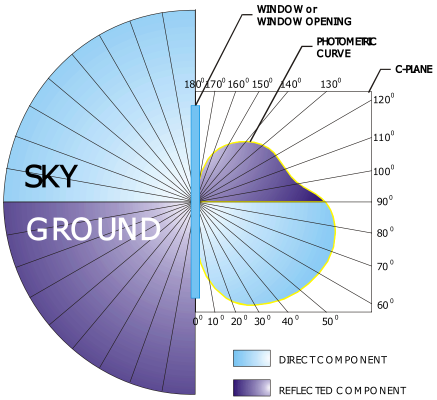

Figure 5 Influence of direct and reflected components on photometric curve

When calculating a reflected component it is very important to take into consideration reflectance of outdoor ground. If outdoor ground has low reflectance (e.g. dark grass), the upper part of the photometric curve will only have small influence on indoor illuminance. On the other hand, if outdoor ground reflectance is of a great value (e.g. snow), we can expect that the reflected component of light will have a great influence on indoor illuminance. In this version of our software a Lambertian surface is taken for outside ground.

The indirect component of light coming to the point of observation in a room will be calculated by the simulation programme itself. Photometric data, which is recorded in a file, contains luminous intensity data for a window or a window opening for all directions in the hemisphere looking into the room, not only for the direction of the point of observation.

5. Calculation of photometric curve

Before calculating a single luminous intensity in photometric curve, we have to find a link between the luminance of a sky patch and the luminous intensity of a substitutive light source. When searching for the link an equation, which connects the luminous intensity of a light source and the luminance of an apparent shining plane, is of great help.

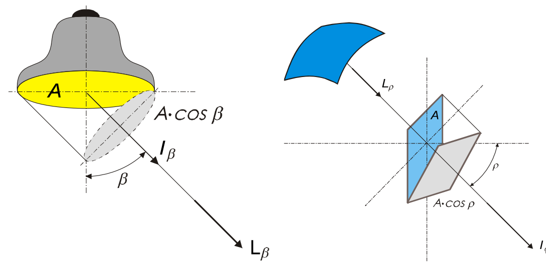

Figure 6 Connection between luminous intensity and luminance for a luminary and connection between luminance of a sky patch and luminous intensity.

The luminous intensity of a light source, which substitutes windows or window openings in a certain direction defined by an a an angle (ρ), is equal to the product between the luminance of a sky patch in the same direction (L_ρ) and the orthogonal projection of a shining plane (window or window opening) onto this direction ($A \cdot \cos\rho$).

$$I_\rho = A \cdot \cos\rho \cdot L_\rho \qquad \text{[Eq. 1]}$$

Equation 1 represents the basis for calculation of luminous intensity values at all vertical and horizontal angles.

6. Defining the right sky patch

As already mentioned, the calculation of luminous intensity is based on equation 1. But we need to consider that both vertical and horizontal angles have influence on the apparent size of shining plane of a substitutive light source. The extended equation for luminous intensity is:

$$I_{\Theta,\varpi} = A \cdot \sin\Theta \cdot \sin\varpi \cdot L_a \quad \text{[Eq. 2]}$$

where:

$I_{\Theta,\varpi}$ luminous intensity of substitutive light source in certain direction,

A window surface,

Θ vertical angle,

ϖ horizontal angle,

L_a luminance of a sky patch.

Before calculating luminous intensity, the right sky patch has to be defined. Every patch is uniformly defined with two coordinates. The first one is the angle of elevation above horizon (γ) and the second is the azimuth of a patch (α).

The equation, which defines the angle of elevation above horizon, has to be defined partially (shown on Figure 7).

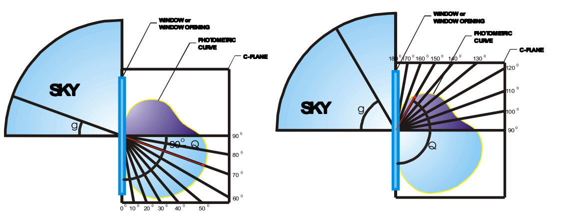

Figure 7 Defining angle of elevation above horizon for sky patches

The first part defines the angle for the direct component of a light (vertical angles between 0^0 and 90^0), the second one defines the angle for reflected component of a light (vertical angles between 90^0 and 180^0). The partial equation is:

$$\gamma = \begin{cases} 90^0 - \Theta; & 0 \le \Theta < 90 \\ \Theta - 90^0; & 90 \le \Theta \le 180 \end{cases} \quad \text{[Eq. 3]}$$

where:

γ angle of elevation above horizon,

Θ vertical angle.

We formulated the equation for a vertical angle in a C-plane with the angle of elevation of a sky patch. Similarly, it is necessary to define the connection between the vertical angle in a C-plane and the azimuth of a sky patch. The explanation for the equation is more obvious, if we take a look at Figure 8 first.

The connection between the horizontal angle, window orientation and the azimuth of a sky patch is handled in the following equation:

$$\alpha = \zeta + \varpi - 90^0 \quad \text{[Eq. 4]}$$

where:

α azimuth of a sky patch,

ζ window orientation,

ϖ horizontal angle.

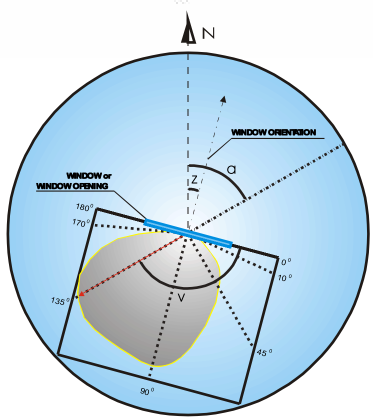

Figure 8 Connection between horizontal angle and azimuth of a sky patch

7. Module 'Photometry'

This module calculates photometric data for a light source, which substitutes a window or a window opening and presents it in a table. Luminous intensities are listed in a CP for all combinations of vertical and horizontal angles (shown on Figure 8).

For a correct calculation of photometric data more data is needed for input. The size of a window is of course one of them. Window surface can be input by selecting appropriate height and width of the window. Transmittance of glazing material can be chosen as a percentage value. As argued before outdoor reflectance has a great influence on indoor illuminance. Outdoor reflectance is also input by selecting an appropriate value from the list-box. To come to a credible calculation it is necessary to enter the building's orientation. This is defined in two steps.

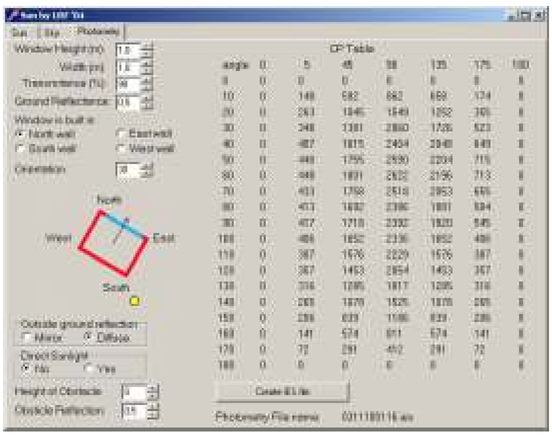

Figure 9 User interface of module Photometry

The first step is to select the wall of the window or the window opening and the second relates to defining the exact wall offset. Every time a new selection of window's orientation is entered, a picture of the building and of the Sun is drawn. The picture presents the building's true orientation and the azimuth of the Sun, thus it can be immediately found out, if direct sunshine can be expected in a room. As the new CIE standard uses only contribution of a sky and does not take into account direct sunlight, the results of simulation are not comparable with real-life cases and measurements, if there is a direct sunlight in the room. When all input data is entered, a CP table on the right side of the module Photometry is drawn up. The table includes luminous intensity for 7 C-planes and 19 vertical angles. By pressing the button "Create .IES file" you create a file with photometric data. The file is a standard IES file (shown on Figure 10) with a unique name. Beside the photometric data there is also data about size and position of the substitutive light source in the file.

```
[TEST] Substitutive light source
[MANUFAC] Laboratory of Lighting and Photometry
[LUMCAT] SUN – Photometry
[INFOLINK] http://lrf.fe.uni-lj.si
TILT=NONE
 2  1200  1  19  8  1  2 .1 1.0 1.0
 1  1  50
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
0 10 45 90 135 170 180 360
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 167 306 411 481 517 520 494 463 459 232 247 260 258 240 206 153 84 0
0 727 1403 1958 2341 2530 2522 2353 2146 2064 1073 1176 1261 1265 1170 979 702 364 0
0 1121 2386 3675 4763 5375 5378 4888 4273 3902 2136 2444 2689 2688 2382 1838 1193 560 0
0 814 1809 2978 4262 5285 5096 4342 3610 3173 1805 2171 2548 2642 2131 1489 904 407 0
0 192 403 608 773 863 863 790 697 644 348 395 432 432 386 304 202 96 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

Figure 10 Example of an IES file

8. Validation of the program

To show the practical value of the window model and to validate its use, we have made some calculations of indoor illuminance distribution with the model and compared it with the measured results. A small room 3.5 m wide, 5.3 m long and 2.57 m high was used as a test room. The room has one window with height of 1.45 m and width of 2.0 m. The window is placed on the south-east wall of the room. The center of the window was 1.6 m above the floor. The room was empty, painted in white with the wooden floor. The reflectance of the walls and ceiling was 0.8 and the reflectance of the floor was 0.4.

First the measurements were performed. We measured the illuminance in the room at the 24 points. The illuminance was measured at the height of 0.85 m which is standardized as a normal working plane.

Altogether 12 measurements were made at the different days between February 2nd and February 6th and also at the different times and weather conditions.

With the IES file, produced with our software, the simulations were made in Lumen Micro for all measurements and results were compared. Resume of results is given in Table 1.

Table 1 Resume of results

Meas. No.	M3	M4	M5	M7	M9	M12	MAX	MIN	AVG
date	3.2.03	4.2.03	4.2.03	5.2.03	5.2.03	6.2.03			
time	15:50	12:30	15:30	9:15	15:50	15:15			
Sky	partly cloudy	snowing, uniform luminance	snowing, uniform luminance	partly cloudy	partly cloudy	more or less clear			
comparable	yes	yes	yes	yes	yes	yes			
min_S/min_M	1.04	1.17	0.81	1.10	1.06	1.53	1.53	0.81	1.12
avg_S/avg_M	1.13	0.96	1.11	1.19	1.03	1.18	1.19	0.96	1.10
max_S/max_M	0.92	1.04	1.24	0.87	0.75	0.92	1.24	0.75	0.96

9. Conclusion

IES file with photometric data for light source which substitutes windows or window openings, created by using our software, can be easily imported into any lighting software that includes the option of importing luminaries. The structure of the file is standardised as for any other luminary, therefore we do not expect any problems when importing files into simulation software. The only thing remaining to be adjusted by the user is to correctly position substitutive light the window. The position must comply with the data given to the module Photometry. The results given by the simulation software present the contribution of daylight to indoor illuminance. With this new software it has now become easier to estimate the available daylight for different seasons and skies and different times of observation. Having all that at our disposal the luminaries or lighting systems can be much more efficiently designed.

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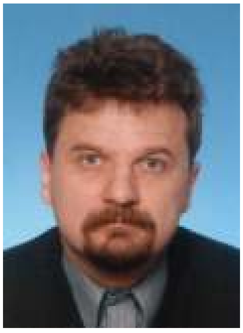

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RESIDENTIAL ENERGY EFFICIENT LIGHTING,
Compact Fluorescent Lamps Promotional Campaigns Under the Frame of Romanian and European Projects

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Both in European Union countries and in Romania, the residential sector represents an important potential for the reduction of energy consumption. The energy consumption in this sector is focused on lighting, domestic appliances and heating/air conditioning/hot water.

The Lighting Engineering Center of the Technical University of Cluj-Napoca (LEC UTC-N), Romania is involved in two programs for promoting lighting energy efficiency and energy saving measures in residential buildings: ***EnERLIn*** *- European efficient residential lighting initiative is an EIE - SAVE program to promote Compact Fluorescent Lamps (CFL) in the residential sector, to propose and validate robust scenarios for CFL promotional campaigns on European, national and regional levels.* ***CREFEN*** *Integrated software system for energy efficiency and saving in residential sector, is a Romanian CEEX program, to achieve an integrated software system for reducing the energy consumption and promoting an advanced energy management in residential buildings in Romania.*

1. EnERLIn - European Efficient Residential Lighting Initiative

The European Climate Change Programme (ECCP) identified residential lighting as an important area to CO_2 emission reductions. After a considerable number of promotion and rebate schemes, about 135 million CFLs are used today in European homes. However, only 30% of EU households have at least one CFL, with those households that own them having an average of three or four. The EnERLIn EIE SAVE program is aiming at promoting to all the stakeholders a quality charter to assure that the CFL that are marketed and promoted can deliver savings which last overtime and meet the customer expectations of high quality lighting, and the ultimate objective of the program is to substantially increase the efficiency of residential lighting in a number of Member States and Candidate Countries.

The residential lighting market is still dominated by inefficient Incandescent Lamps (GSL General Service Lamps). The EnERLIn EIE SAVE program proposes to develop and validate robust scenarios for CFL promotional campaigns in European, national and regional levels. Concerning energy savings from CFLs, assuming that there is 150 million households in Europe the energy economy by replacing only one additional 75 W GSL by one 15 W CFL is in the order of 22.5 TWh or 4 MTEP per annum, this corresponds to 1.2 Mtonnes of less CO_2 per annum. We should add at these savings that a high quality CFL has a life span higher than 10,000 work hours, compared to 2000 work hours for a GSL.

The European Union initiated numberless campaigns to promote compact fluorescent lamps with the purpose of increasing the market share of CFLs at 15%. The estimated energy saving would amount to 15 TWh per year, similar to a reduction of annual CO_2 emissions of about 800 kTones CO_2.

Objectives of the EnERLIn action

Improving the energy efficiency is a central theme of energy policy within the European Community, as indicated in the White Paper "An Energy Policy for the European Union", since improved energy efficiency meets all the three goals of energy policy, namely security of supply, competitiveness and protection of the environment. Lighting represents an important part of building energy consumption in the EU around 10% of the total electricity consumption, ranging from 5% (Belgium, Luxemburg) to 15% (Denmark, Netherlands, and also Japan).

The global electric lighting energy use may be split in four sectors: services 48%, residential 28%, industrial 16% and street lighting and other 8% [Mills 2002].

Overall electric appliances in households, industry and the tertiary sector represent 40% of the EU total electricity consumption, its generation being one of the most important sources of CO_2 emissions. Within the EU, the households and private and public services sector buildings are important power consumers. In both cases lighting represents a large part of their energy consumption. Several EU and National Initiatives and Directives tented to promote energy efficient lighting for services sector buildings. These efforts can be judged as very successful because nowadays the Compact Fluorescent Lamp (CFL) market share represent 20% of the global European market whereas the same figure in world scale is limited to 17%. The rate of the households owning a CFL covers the range from 0.8 CFLs per household in UK to more than 3 CFLs per household in Denmark; the SAVE projects have found that there is at least room for 8 CFLs per home [Kofod 2002, Loe & Jones 2002, *DELight* 1998]. An analysis on the lighting pattern in 100 Danish homes denotes that the monthly average lighting consumption varies between 5% and 21% of the total respective monthly consumption, and 24% of the lamps are energy efficient lamps (linear fluorescent lamps or CFLs). However, the same market analysis from Lighting Companies show that in Western Europe energy inefficient incandescence lamps (including halogens) still represent 30% of the sales [10]. The bulk of these inefficient light sources concern the residential sector.

The ultimate objective of this program is to substantially increase the efficiency of residential lighting in a number of Member States and Candidate Countries, and this can be done by offering them good arguments necessary to overcome the above cited barrier. It is also important to promote the wide-scale availability of a high spectrum of low-cost CFLs suiting a wide range of needs including different sizes, shapes, colour rendering, wattage (particular problem in some counties like Hungary is that the typical good CFLs are of lower wattage and therefore provide limited illumination levels), and bases. Furthermore, to achieve successful residential market transformation we should promote that both light fixture outlets as well as design and specialty stores display their luminaires with CFLs (good and aesthetic ones) rather than GSL. At the same time the program is aiming at promoting to all the stakeholders a quality charter to assure that the CFL that are marketed and promoted can deliver savings which last overtime and meet the customer expectations of high quality lighting.

All the program objectives will lead to a higher market share for the most efficient CFLs and dedicated luminaires. The main stakeholders concerned by this program are manufacturers' associations, consumers' associations, buyer's groups, energy agencies and other intermediates, utilities, training institutes, retailers, installers and other professions. The final beneficiaries will be end-users of equipment mainly in domestic sector.

2. CREFEN - Integrated software system for energy efficiency and saving in residential sector

The **CREFEN project** aims to creating an integrated software system-tool focused on the applications concerning the electric energy efficient use and saving in residential sector in Romania. The project integrates the consumption assessment and prognosis methodologies, consumption scenarios, consumers' guidance and training to the advanced technologies, sustainable electric energy management and the economical, social and environment impact, as well. A special issue is to develop the necessary databases of equipment and endowments from residential sector, using the market surveys and questionnaires.

The project aims to develop an advanced modeling and simulation software system-tool of electric energy consumption in residential sector and of economical effects, to implement an application with databases, an interactive educational application and electronic book related to the energy efficiency use in order to influence the consumers' options in selecting energy efficient appliances for environmental protection by reducing the CO_2 emissions.

The **National Strategy in the energy efficiency field** adopted by the HG 163/2004 underlines that the residential sector has a primary energy saving potential at 3.6 millions tones equivalent petrol through 6.8 million tones of the total final consumers; it means more than 50%. This potential can be capitalized by the rehabilitation of the buildings heating insulation, the improvement of the heating and lighting systems and of the electric domestic appliances. The legislative frame was created and is on line with the EU acquis, the EU Directives related to labeling of the energy parameters for many electric appliances.

The **Governmental Program** on the following years 2005-2008 states the necessity to accomplish the legislative and institutional frame in order to apply the flexible mechanisms adopted by the Kyoto Protocol, to pursue the implementation of the technical and economical measures for the reduction of the gas emission with the greenhouse effect, in accordance with the features of the National Plan for the Allocation of the Emission Quotas, the development of the National Plan for

Climatic Changes Action, the improvement of the energy efficiency and the promotion of regenerate energies.

The **specific objectives** of the CREFEN project are:

- Drawing up of scenarios and prognosis of electric energy consumption in residential sector;
- Achievement of an advanced modeling and simulation software system-tool of electric energy consumption in residential sector and of economical and environmental effects;
- Using a tool for defining the potential of energy saving, prognosis and scenarios of consumption evolution;
- Improvement of the degree of taking into consideration by the consumers, decision factors and specialists of the opportunities, advantages of promoting new technologies in electric energy consumption in residential sector, in the framework of a sustainable development integrated at the European level;
- Designing and implementation of a web application with databases for domestic and lighting appliances available on the Romanian market, which include information from the energy label and sheet;
- Designing and implementation of the software for an interactive system and an electronic book.

The project is connected with energy efficient use according to EU directives from one side and with the implementation of database applications using web-based technologies for assisting and influencing the consumers decision in selecting the domestic and lighting appliances from the other side, that leading to sustainable environment management. The last aim of the project is for environmental protection by reducing the CO_2 emissions.

The software application architecture will be a modular one, with the possibility of its extension with new functionalities, without perturbing the other components or requiring the reorganization of the system data.

LEC UTC-N work**s** in the CREFEN project aims: (1) to analyze the Electric Lighting component in the energy balance of the dwelling; (2) to elaborate a simplified mathematical model for calculation of the inside electric lighting; (3) to present the IT system to technical background users groups (students, designers, dealers and retailers); (4) to contribute with the chapter Electric and Natural Lighting of the design specification for IT system; (5) to analyze the direct energetic and educational benefits and evaluate the importance and the impact of the improvement of the domestic users education; (6) to design consumption evaluation scenarios based on the evolution of the technological performances of the new lighting equipments (for 5 and 10 years); (7) to print an informing flyer concerning the electric and natural lighting component; (8) to promote the project achievements by workshops, the Ingineria Iluminatului (Lighting Engineering) journal and the ILUMINAT international conference.

3. Analysis of electric lighting energy consumption in the residential sector in Romania

The statistic data [12] for the period 2000 2004 allow us to determine the average consumption per household consumer in Romania Figure 1.

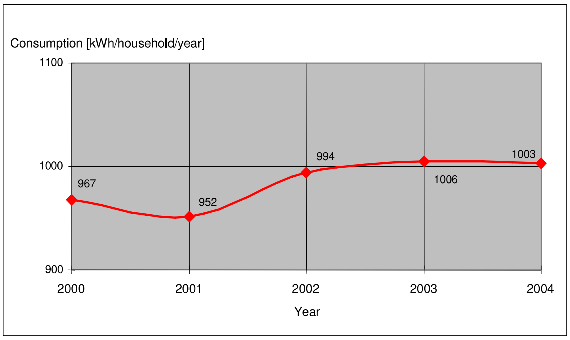

Figure 1 Average energy consumption per household in Romania 2000-2004

The analysis of the presented data allows us to estimate a few characteristics of electric energy consumption of households Table 1.

At the level of the EU, according to "Energy efficiency indicators in Europe" Odysee [1], the residential consumption in 2003 was of 2533 kWh/household/year. We remark that in Romania this consumption is of about 40% of the EU level.

We currently have little information with respect to the electric lighting contribution to the total energy consumption of the households in Romania. As estimation, we may count on the results of the study [4], according to which the electric lighting consumption represents around 25% of the total electric energy consumption of the studied households.

The total annual household consumption in Romania has been determined considering the sales of Electrical National Company towards the household consumers and the average contribution of the consumption on the lighting circuits (25%); The annual electric lighting household consumption per m^2 was determined based on the average household surface in Romania in 2002 - 37.39 m^2/household; an average exchange rate of 3.50 RON/Euro.

A comparison of the information presented in [5] to the data presented in this study is shown in Table 2

Table 1 Characteristics of electric lighting energy consumption in households in Romania.

Year		**2000**	**2001**	**2002**	**2003**	**2004**
Total annual electric lighting consumption	[$x10^3$ MWh]	1,938	2,028	1,996	2,028	2,036
Annual electric lighting consumption per household	[kWh/household/year]	246	257	253	256	255
Annual electric lighting consumption per m^2	[kWh/m^2/year]	6.58	6.87	6.76	6.84	6.83
Annual cost of electric lighting consumption per household	[euro/household/year]	38.57	39.57	39.19	39.47	39.42

Table 3 Light source usage statistics for GSL and CFLs in Romanian households.

Household		**GSL**		**CFL**		**Installed power**
Type	No.	Units	Average	Units	Average	kW
Apartment	220	2624	11.98	367	1.67	0.770
Single-family house	75	1088	14.51	196	2.61	1.028
Total	295	3712	12.58	563	1.91	0.835

Table 2 Characteristics of electric lighting energy consumption in the residential sector in Romania; comparative study based on data in [1] and [5].

	DELight 1998	UTC-N 2005
Electricity consumption		
Total electricity consumption (TWh/an)	60.0 (1996)	33.8
Residential electricity consumption (TWh/an)	7.1	8.001
Residential lighting electricity consumption (TWh/an)	n.a. (1996)	~2.036
Household lighting – Information		
Household lighting electric energy consumption (kWh/an)	n.a. (1995)	~255.3
Number of lamps per household	9	11.5
Average number of CFL per household	0.006 (1995)	1.11
Household ratio using CFL	0.5 (1995)	0.47
Average number of CFL per household using CFL	1.1 (1995)	4.02
Number of luminaires per household	5.5	7.16
Households – Information		
Number of households ($x10^6$)	7.78 (1995)	7.97
Number of persons per household	2.91 (1994)	2.63 (2002)
Average surface (m^2)	n.a.	37.39
Prices	1996 (ecu)	2005 (Euro)
Price of electric energy per kWh 0 – 50 kWh	0.008	0.38
50 – 100 kWh	0.019	
>100 kWh	0.041	0.0921
	ecu	Euro
Price of GSL	0.3	0.43
Price of CFL	13.2	4.3

The total energy consumption dropped from 60 TWh/year in 1996 [5] to 33.8 TWh/year in 2005, according to the data received from the national company of electricity. For the same period, the weight of the residential consumption increased significantly, partly due to the massive reduction of industrial consumption after 1989, but as well, to a continuous increase of the number of household subscribers.

Figure 2 shows the spreading of different types of lamps used in household lighting in a few countries in Europe New Member States and Candidate Countries [2]

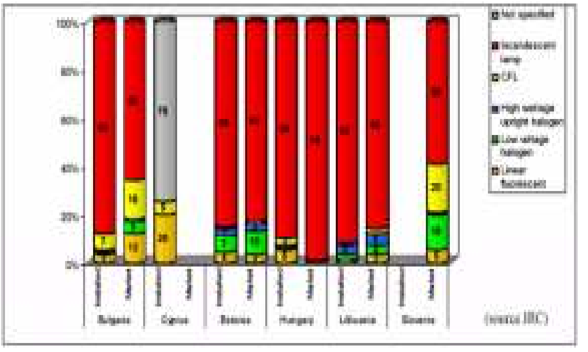

Figure 2 Residential electric lighting in a few countries in Europe – spreading of different types of lamps, Source JRC

The cost of CFLs mainly depend on their life span, the cheapest having a life of 3 years, the typical cost in Romania being between 2.9 - 4.3 Euro, and the more expensive ones have a life span of 8-10 years and a price of 8.6-11.4 Euro. Since the electric energy consumption of these lamps is much lower and has a much smaller cost (only 20% of the cost of GSL, the cost of the initial investment may be recovered in 3-12 months, depending on the cost of the CFL, after which up to 8.0 - 9.0 Euro per lamp per year is saved.

The use rate of CFLs is from 0.8 units per household in Great Britain up to over 3 units per household in Denmark. Projects from the SAVE programme consider as a reasonable upper limit the use of up to 8 units per household. An analysis of the residential lighting, realized in 100 households in Denmark, shows a lighting consumption of between 5% and 21% of the total monthly electric energy consumption of the household and the use of 24% saving lamps linear fluorescent lamps and compact fluorescent lamps.

During November 2005 a study has been realized using feed-back reply forms concerning the usage degree of GSL and CFLs in households in Western Romania. We received 295 replies, namely 220 apartments (with 14 rooms) and 75 houses (with 2more than 7 rooms). The light source equipment in these households is presented in Table 3.

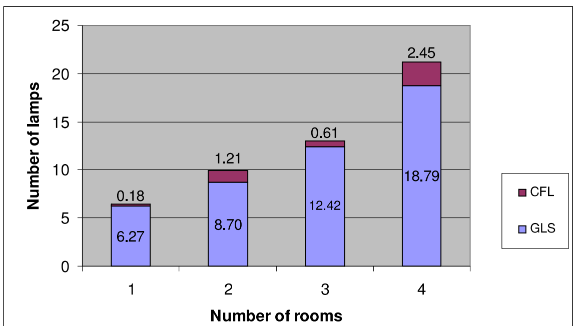

Figure 3 Variation of the number of lamps on apartments with the number of the rooms

The variation of the number of lamps of type GLS and CFL on household type, based on the number of rooms, is represented in Figure 3 for apartments, respectively Figure 4 for houses.

From the analysis of the data presented above we may conclude that the CFL energy

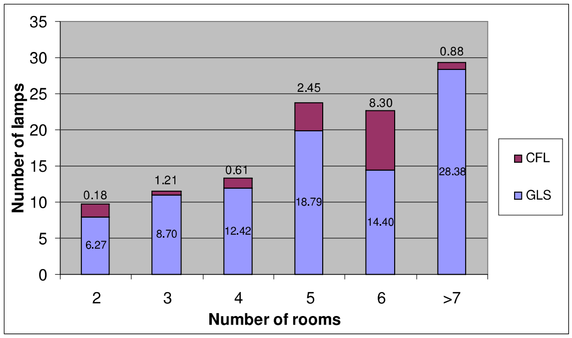

Figure 4 Variation of the number of lamps on houses with the number of the rooms

saving lamps are bought by people with high earnings, which own houses.

We consider the equipping degree with CFLs of approximately two units per household is high, and this denotes the interest of Romanian consumers for buying energy saving lamps.

4. Replacing GSL with CFL

Designing and implementing an energy efficient lighting system in new residential buildings is an initiative involving large perspectives concerning the achievement of long term energy savings. Such a system will be based first on the replacement of GSL with CFL at a large scale. The main impediment in adopting an efficient energetic lighting system in new buildings is the price difference between the conventional lamps and the economical once. In designing lighting systems for residences a large number of players are involved: the architect, the designer of electrical appliances, the entrepreneur, the equipment supplier and the beneficiary. Few among these have technical qualification in lighting design, not to mention efficient energetic residential lighting.

The simple replacement of the old lamps with new, more efficient ones, for a

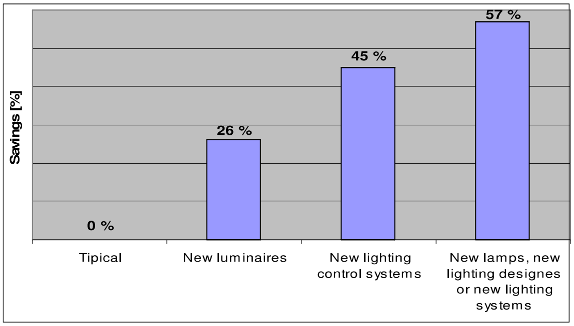

Figure 5 Savings using alternative lighting systems, instead the old conventional ones [7]

household is the most common way of getting electricity savings of about 26%. Approaching a new lighting design we can save around 57% electricity - Figure 5. [7]

5. Conclusions

The estimative values of total electric energy consumption and the total lighting energy consumption in the residential sector, presented as a conclusions of our study, are of 255.3 kWh/household/year, and 25% of the total household electric energy consumption, values that fit in the limits presented by the specialty literature.

The mounting of a single CFL in each household of Romania would lead to a decrease of the household electric energy consumption of around 45,246 MWh/year. The estimation has been realized on a theoretical evaluation, based on 2,036,000 MWh/year (the household electric lighting energy consumption - 2004) divided to 9 (average number of lamps per household in Romania (Table 2) and then to 5 (the ratio between the electric energy consumption of a CFL and a GSL with the same luminous flux). This value corresponds to a saving in the CO_2 emissions of about 2.5 kTonesCO_2 (1 kWh=0.0536 kg CO_2 according to the average values considered for European countries).

Other than achieving important electric energy savings and cuts in costs and in polluted emissions, the introduction of efficient lighting technologies in the case of household consumers presents a different, important advantage, namely the reduction of the maximal absorbent power in the morning and evening consumption peaks.

The predicable economic impact of this study will be established by the adoption of policies towards an electric energy consumption reduction, both locally and nationally. It is essential to increase the awareness of the energy efficiency problem both by users and by the electric energy providers, in order to reduce the consumption peaks that are specifically due to lighting.

6. Acknowledgments

This work was prepared with financial support from the European EIE - SAVE ***EnERLIn*** and Romanian CEEX ***CREFEN*** programs.

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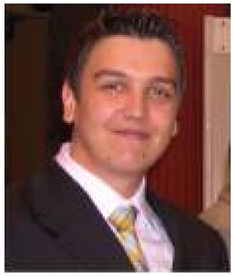

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He graduated the Technical University of Cluj-Napoca in 2004. The theme of his graduation diploma is on Researches in Building Energy Management Systems (BEMS). Presently he is studying for the PhD. He attended a training programme in the energy efficiency field, working at the Joint Research Centre in Ispra, Italy on the GreenLight Programme (2005-2006).

Paper accepted at the 1st International Conference on Modern Power Systems MPS 2006, November 8-11, 2006, Cluj-Napoca, ROMANIA

PROGRESS ACCOMPLISHED IN THE FRAME OF EnERLIn PROJECT DURING THE FIRST 6-MONTH OPERATION

Georges ZISSIS, EnERLIn coordinator
CPAT-University Toulouse 3

1. Project objective

The overall EnERLIn project objective 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 objective should be achieved mainly by

- Introducing a CFL Quality Charter that guarantees for the end-user the CFL quality;
- Designing and implementing CFL promotional campaigns adapted to each country sensibility.

Summary of activities and results for the reporting period

During the 6 first months of the project the following activities have been initiated or achieved

- The project advisory committee (AdCom) has been constituted
- The project web page is now operational and accessible in: http://www.enerlin.enea.it
- The CEN-STAR label has been officially obtained for a CFL-Quality Charter seminar that it will be held during 2007.
- Data from several countries (not limited to project partners) concerning CFL market (price, volumes, shares) and residential use (number of lamps per household or/and square meter, number of hour of use) have been collected. The data are now under analysis and consolidation.
- Elements from previous CFL promotional campaigns are under collection and analysis.
- A first scenario of energy consumption for lighting for the residential sector is established and will be refined in the next months.

Some key results

One of the first tasks carried-out during the first 6-month operation of the project consisted on the the collection of various data concerning CFLs and energy consumption for lighting. These data will be analysed during the following months and they will be integrated in database that will be accessible via the project page.

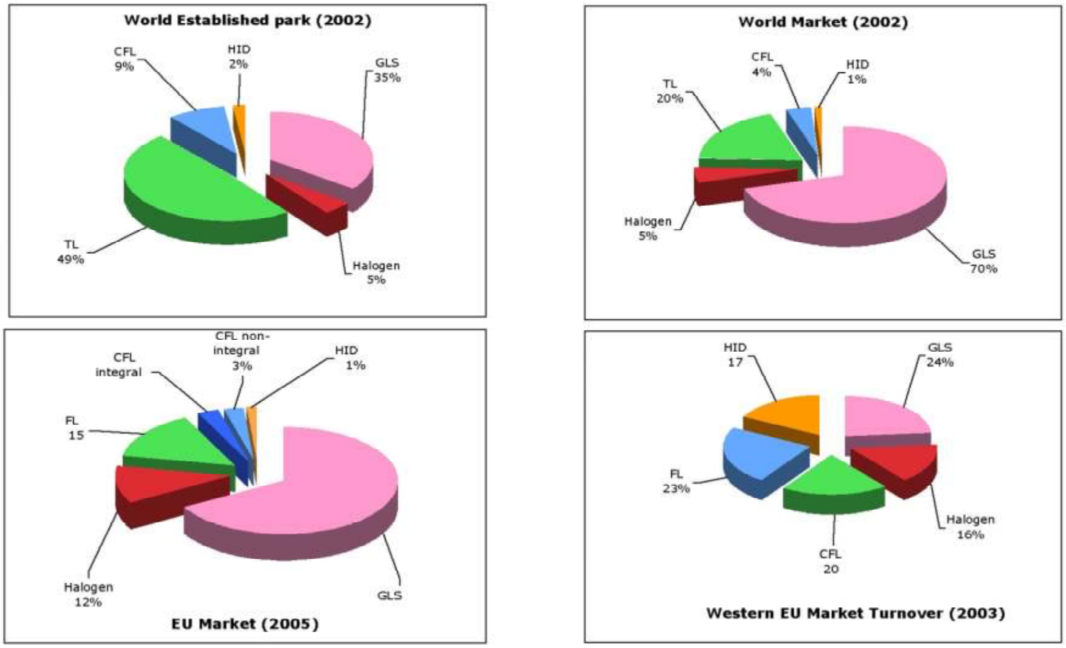

Figure 1 Data concerning the world and European lighting market

As example, the coordinator collected information concerning general lighting market in Europe and worldwide. These information represented in the following graphics are obtained from Lighting industry passing trough the EU-COST-529 “Efficient Lighting for the 21st century” network.

In parallel, in Denmark, Dansk Energi investigations in the frame of EnERLIn, show that about 30% of the Danish residential sector has zero CFL's. As seen from the figure, the penetration has been somewhat slow in the early nineties, but reaches even though a level of ca. 5 CFLs per household in average. This is about 20% of the total stock of lighting sources in Danish households. The sales of CFL's have climbed to ca. 3 million in 2005. Two important issues have to been taking under consideration. First the replacement rate of CFL's in Denmark is not well known. Second reliable methods to calculate and verify the savings from implemented CFL's need to be improved. A third important issue is to promote more costumer oriented information such as description of bad and good quality. This last issue has been pointed out also by Ecodoma in Latvia based on the market growth observed during the past years due to ELI promotion of good quality CFLs.

In Romania, UTC-N, realized an exploratory study[1] using feed-back reply forms concerning the usage degree of General Service incandescent Lamps - GSL -

[1] *The Questionnaire Campaign was performed under the frame of the Romanian CEEX program CREFEN. The specific data referring to the Lamps usage - GLS and CFL - were collected only on the UTC-N questionnaires for the use of received information under the frame of the IEE program ENERLIN, as an explanatory study.*

and Compact Fluorescent Lamps - CFL-, energy consumption and installed power in households in Western Romania.

To that questionnaire action 295 replies have been received, namely 220 apartments (with 14 rooms living room and bedrooms) and 75 houses (with 2more than 7 rooms living room and bedrooms). The state of the facts is presented in Table 1, and the usage of the light source equipment in these households is summarised in Table 2.

The installed lighting power has an average value of 0.835 kW/household which is still very modest comparing to western countries. This lead us to discuss the second achievement during the 6-month period: the establishment of a very simple model concerning energy consumption for lighting in the residential sector.

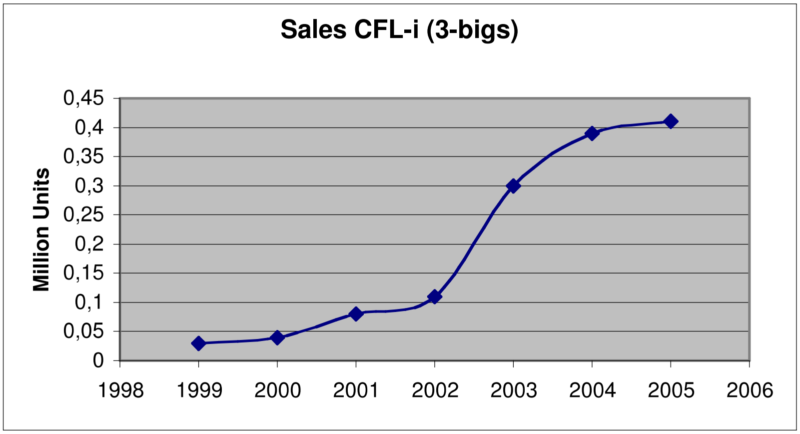

Figure 2 Sales of CFLs in Latvia. The rapid growth observed in this graphics is due to ELI promotional campaigns in Latvia

Energy saving policies and environmental constraints imposed by European regulations push strongly to develop “green” solutions for lighting. At the present case, CFL seems to be the most valid solution. Several European and national programs are devoted to the promotion of this type of lamps and try to limit the GLS use in households. These campaigns are today very efficient and the number of CFL sales increases in Europe rapidly. The average observed growth rate concerning CFL numbers is the order of 13.5% per year (in the order of 11.5% in western and 17% in eastern countries). We should notice that the annual growth rate of the global lighting industry is in the order of 0.8%.

However, the evolution of CFL efficiency is very slow, someone can expect that it will attain, in average, 63lm/W in 2030. According to Photonics21 Consortium there are two new technologies that can be responsible for a breakthrough in the domain of residential lighting: Light Emitting Diodes

Table 1 Questionnaires data for Light source (GSLs and CFLs), Energy consumption and Installed power in Romanian households (January 2006)

	Number of			Energy consumption [kWh]	Number of lamps		Installed power [W]	
	rooms	households	people		GSL	CFL	Total	Average
Apartment	1	11	21	1213	69	2	5060	460.00
	2	76	218	10,203	661	92	42,296	556.50
	3	95	296	16,983	1180	180	80,045	842.60
	4	38	130	6551	714	93	41,929	1103.40
Total Apt.		**220**	**665**	**34,950**	**total 624 av. 11.93**	**total 367 av. 1.67**	**169,330**	**769.70**
Single-family house	2	13	40	1369	103	24	7120	547.70
	3	14	44	1935	154	7	11,120	794.30
	4	17	63	3099	202	25	13,350	785.30
	5	13	46	2110	258	50	16,168	1243.70
	6	10	37	2030	144	83	10,714	1071.40
	>7	8	26	2396	227	7	18,605	2325.60
Total SFH		**75**	**256**	**12,939**	**total 1088 av. 14.51**	**total 196 av. 2.61**	**77,077**	**1027.70**

Table 2 Light source usage statistics for GSL and CFLs in Romanian households (January 2006)

Household		GSL		CFL		Installed power kW
Type	No.	Units	Average	Units	Average	
Apartment	220	2624	11.93	367	1.67	0.770
Single-family house	75	1088	14.51	196	2.61	1.028
Total	295	3712	12.58	563	1.91	0.835

(LED) and Organic Light Emitting Diodes (OLED). LED technology seems to be mature enough in order to take some part of the domestic lighting. Today some "design" luminaries with LEDs are proposed for sale, but the price is prohibitive. Today, the efficiency of white LEDs is in the order of 25 lm/W (in series production) but according Photonics21 Consortium this can attain the value of 150 lm/W in 2025-2030 and according to George Craford the price of LEDs is decreasing by a factor of 10 every decade. We will use these figures in our projections. On the other hand OLED technology seems to be very promising because of the fact that OLEDs in opposite of LEDs constitute large "etendue" light sources. However, even if Osram shown very recently a OLED panel with 20 lm/W efficiency [Navigant Consultans, Solid-State Lighting Research and Development Portfolio, Lighting Research and Development Building Technologies Program Office of Energy Efficiency and Renewable Energy U.S. Department of Energy, March 2006], this technology is still in experimental stage and it is difficult to expect that can get a significant part of the residential lighting market by 2030. It is also very difficult today to predict what will be the cost of this technology for the next years. Concerning LED and OLED there is not any environmental charge that is included today to these light sources. However, LED industry, like semi-conductor industry, can be considered as relatively harmful for the environment. It is not excluded that by 2030 LED technology will have to support also an environmental charge for recycling like CFLs. Under all that assumptions we construct 3 possible scenarios for 2030:

Basic scenario: In 2030 only CFLs and GLS have a significant part of the market, LEDs and OLEDs quantities are negligible because of slow technological development and high prices. Then taking into account the annual growth rate of CFLs as given above we can consider that in 2030 each household will have 45% CFLs and 55% GLS.

Consumerist scenario: In 2030 CFL price still high compared to a GLS and the CFL promotion campaigns fail to convince consumers about the utility of CFLs, in addition LEDs and OLEDs quan- tities are negligible because of slow technological development and high prices. Under these conditions in a household we will find 75% of GLS and 25 of CFL. A second "consumerist + 10 lamps" scenario is also considered; in that case the number of lamps per household is increased by 10 (38 lamps instead of 28).

Green Scenario: In 2030 CFL prices are comparable to GLS, CFL quality is guaranteed by a European label. LED technology is well advanced and price is now affordable for consumer that may use this type of light sources for decorative and punctual lighting. OLEDs are now available but the price is still high, thus the quantity per household is negligible. The light source park of an average household will include 75% CFL, 15% GLS and 10% LEDs. For environmental protection purposes the consumer is convinced that it is not necessary to increase the quantity of light in his home. Keeping in mind that GLS and CFL average power are 60 W and 15 W (no significant change in the efficiencies since 2006). The above requirement of constant light quantity lead to an average power of 5 W per light source using LEDs. It should be noticed that an efficiency of 100 lm/W is used in our calculations, this value is 50% less than the targets pf Photonics21 ["Toward a Bright Future for Europe", Strategic Research Agenda in Photonics, Photonics21 European Technology Platform Consortium, ISBN-3-00-018615-8, April 2006] but it seems to be more realistic for industrial production in 2030.

Before evaluating the impact of each scenario in the energy consumption of an average household it is necessary to evaluate the expected number of light sources per household in 2030. For this purpose we consider that the number of light points per household increases with an annual rate of 0.5% (which is lower than the annual growth rate of the lighting industry sited above). This leads to 28 light points per household in average. The following excel table calculates the impact of each scenario on the average energy consumption per household.

This very simple calculation shows that, compared with the actual situation, in the case of Basic scenario a decrease of 21% on the lighting consumption of the household is observed for an increase of 13.9% of total light quantity. Pure consumerist scenario leads to 1% increase of the energy consumption for only 11.8% additional light quantity. If we use the "reinforced consumerist" scenario the light quantity is increased by 35.4% in the household (this is probably not justified by visual comfort considerations) and the energy consumption is increased by 24%. Finally, the Green scenario leads to a 13.6% light-increase (compared to 2006) but similar that obtained in 2030 by the basic scenario and that for an energy gain of 132% compared to 2006.

The following table shows the impact of the different scenarios in European level compared to the 2006 situation. For this calculation the growth rate of household number has been included.

Impact on energy consumprion for Lighting at European Level

Anual Growth rate %	0,7		
	2001	*2006*	*2030*
Number of Households (millions)	140	144,9	163,52

Scenario	2006 Energy TWh	2006 Energy MTEP	2006 CO2 Mtn	2030 Energy TWh	2030 Energy MTEP	2030 CO2 Mtn	Variation %
Reference	391,2	100,9	208,9				
Basic				364,0	93,9	194,4	-7,0%
Consummerist				446,4	115,2	238,4	14,1%
Consummerist+ 10 lamps				577,9	149,1	308,6	47,7%
Green				190,0	49,0	101,5	-51,4%

1 TWh = 0,258 MTEP
1 TWh = 0,534 Mtn CO2

How avoid the "Consumerist" scenario and all catastrophic incidence to energy rational use and environment? A first answer to that crucial question is to identify the reasons that may refrain consumers from CFL use in residential sector. Up to day EnERLIn consortium identified the following fundament reasons:

- 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 are not reliable
- Return time is short but "diluted" and directly observable
- Plug & Play CFLs are not dimmable (this concerns the large majority of

existing products)

- 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

Efficient CFL-promotional campaigns should take into account theses negative arguments and find the way to demonstrate to end-users that valid solutions exist. This will be the work that has to be done during the next project phases.

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INVITATION

The 4th International Conference ILUMINAT 2007

Cluj-Napoca, Romania
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First announcement and Call for papers

The conference main themes are
Lighting Energy Efficiency and **New Trends in Lighting**
developed on the following sections:

Vision and Colour
Interior Environment and Lighting Design
Day-Lighting and Integrated Systems
Exterior Lighting
Light and Architecture
Lighting Installations
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The conference is open to the papers in Romanian and English - there will be simultaneous translation during sessions.

Dates:	31 January 2007	Submissions of abstracts and/or return registration form.
	12 February 2007	Notification of acceptance and instructions to prepare the papers.
	16 April 2007	Submission of final papers to be included in the Conference Proceedings. Late submissions may be printed in INGINERIA ILUMINATULUI journal.

The registration fee - 100 Euro - covers the proceedings, refreshments and the Opening Cocktail (30 May). The Farewell Party (1 June) will be offered by sponsors.

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The 4th International Conference ILUMINAT 2007 Cluj-Napoca, Romania will provide a unique regional 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 represents the community of lighting professionals from Romania, European Member and Associated states and outside from EU area, including lighting and building science researchers, engineers, system designers and project managers, academia and experts, architects and urban planners, local community and government representatives, policy makers, national and international organizations and agencies, manufacturers and retailers organizations, students. The participation of young researchers will contribute to the success of the conference and to the improvement of their knowledge.

The Lighting Engineering Center of the Technical University of Cluj-Napoca (LEC UTC-N), Romania is involved in two programs for promoting lighting energy efficiency and energy saving measures in residential buildings: EnERLIn - European efficient residential lighting initiative, an EIE - SAVE program to promote Compact Fluorescent Lamps (CFL) in the residential sector, and CREFEN – Integrated software system for energy efficiency and saving in residential sector, a Romanian CEEX program. There will be submitted reports on the dedicated work under the frame of these programs.

The two-day conference will include invited lectures where key representatives and high specialists will present their views, programmes and research to advance energy efficiency in lighting. Dedicated sessions on specific themes and topics will allow in-depth discussions among participants. Round tables organized by the official sponsors will present the latest economic and technology achievements of national manufacturers and retailers in electric and lighting fields. The conference will allow the best knowledge of new policies and strategies to increase energy and economic efficiency, to mitigate climate change and to foster sustainable development, to build international partnerships among lighting professionals, to emphasize their cooperation.

PETNAJSTO MEDNARODNO POSVETOVANJE
FIFTEEN INTERNATIONAL SYMPOSIUM

RAZSVETLJAVA 2006
LIGHTING ENGINEERING 2006

Lighting of Work Places
October 12th and 13th 2006
and
CEREMONY

to celebrate 50 years of SDR
October 13th 2006 at 15:30

HOTEL ASTORIA
BLED, SLOVENIA

Program / Programme

Thursday, 12th October 2006

8:30 Registration of participants in Hotel Astoria in Bled
9:00 Opening of the Conference
- Word from the chairman of the organizing committee
- Speech from president of Lighting engineering society of Slovenia
- Speech from minister of Higher Education, Science and Technology

9:30 Opening session

Marc Fontoynont
New challenges in lighting

9:50 Presentation of papers.
Chairman: **doc. dr. Grega Bizjak.**

Liisa Halonen
IEA ECBCS Annex 45 - Energy Efficient Electric Lighting for Buildings

Florin Pop
Energy efficiency in INTERIOR Lighting a Romanian case study

Janos Schanda
New possibilities of indoor electric lighting - the use of LEDs, advantages and problems

Anna Pellegrino
Lighting control systems to improve energy performance and environmental quality of buildings: limits and potentials

11:30 Coffee break
12:00 Presentation of papers.
Chairman: **dr. Marta K. Gunde.**

Christian Bartenbach
Lighting of spaces with VDT´s considering the requirements and processes of visual perception

Henri Juslen

Lighting and productivity in the industrial working place

Martine Knoop

Dynamic Lighting for well-being in work places: addressing the visual, emotional and non-visual aspects of lighting design

Tommy Govén

The background luminance and colour temperatures influence on alertness and mental health

Laszlo Beke, Peter Bodrogi

Optimal Color Primaries for Three- and Multi-primary Wide Gamut Displays

14:00 Lunch

15:30 Presentation of papers.

Chairman: **mag. Andrej Orgulan**

Richard Kittler

Typical sky luminance patterns and their new standardisation as basis for daylight calculations

Stanislav Darula

Calculation of window luminances and sky illuminance in side-lit working places

Axel Stockmar

Outdoor Work Place Lighting according to EN ISO 8995-2 (2006)

Peter Raynham

Public Lighting - How and Why?

Torsten Onasch

Arenas in Light, Light in Arenas

17:30 Social event / free

20:00 Dinner

Friday, 13th October 2006

9:00 Presentation of papers.

Chairman: **Marko Bizjak.**

Primož Gspan

Mandatory or voluntary use of standards for workplace lighting

Gorazd Golob

Problems with use of LED lighting in the print office

Andrej Orgulan

Light pollution from illuminated surfaces

Primož Puhar, Grega Bizjak

Measurements of road surface reflectance

Matej B. Kobav

Use of fish eye digital camera as a sky scanner

10:30 Presentation of posters and student work

11:00 Coffee break

11:30 Annual Assembly of the SDR

13:00 Lunch and prize-giving ceremony

15:30 Ceremony to celebrate 50 years of SDR

17:00 Official closing of the conference

LIGHTING IN THE NEW WORLD

Cristian SUVAGAU
BC Hydro, Vancouver

LIGHTFAIR 2006

If you were among the 17,000 attendees of this year's Lightfair International (LFI) edition in Las Vegas, the world might not have seem large enough to gather all the new LED, CFL lamps and myriads of luminaires shown on display.

For those of you who could not be there, it was quite an event. But rest assured, the new products will come to you soon grace to manufacturer agents.

Aside the trade show itself, the education component was split in two:

- a Lighting Institute on Daylighting, Controls and other important lighting topics, right before the beginning of the tradeshow, and
- a series of complimentary seminars during the trade show.

This way, there was enough time to follow advanced lighting education before the tradeshow and still have all the time to wander among thousands of interesting new(er) products.

The 2006 New Product Showcase
A feature component of each LIGHTFAIR International is the New Product Showcase (NPS), an annual awards presentation celebrating the industry's newest product introductions and emerging technologies. The 276 products submitted for the 2006 program - the most submissions ever - were judged by an independent panel of industry experts who brought decades of expertise and passion to the program.

The winners of the 2006 New Product Showcase & Awards were:

- ***Parallels***® from Peerless Lighting. Winner of the Best New Product of the Year Award, the program's highest honor recognizing the best of the best for 2006. Parallels by Peerless Lighting is a minimalist pendant free of cables, cord, and metal housing. Exclusive new optic technology creates a softly luminous quality of light featuring two-step dimming and HOT-5 thermal management.

- ***Equos*** from Philips. Winner of the Technical Innovation Award, recognizing lighting technology excellence**.** Philips Lighting Electronics' Equos is the first dimmable ballast with wireless control. ZigBee compatible, the ballast communicates with up to 65,000 nodes in a mesh configuration, enabling its wireless interoperability with a broad range of devices.

Additionally, LFI 2006 recognized and celebrated Best of Category Award Winners. Here were some of them:

• ***High Output T8 - 6 Switchable Electronic Ballast*** AC Electronics introduces its energy saving, switchable 6, 4, 3, or 2 lamp X 32, 25 or 17 watt T8 High Output, High Ballast Factor electronic ballast. An economical replacement for expensive metal halide fixtures or less versatile T-8 ballasts.

• ***EcoSystem T5 dimming ballast*** Lutron introduces the EcoSystem multi-input addressable dimming ballast for T5 lamps. This ballast integrates daylight harvesting, occupant sensing, personal control, and load shedding in a thin-profile can.

• ***SuperHID™ 1000 W*** Metrolight's SuperHID 1000 W is a dimmable electronic ballast for 500 - 1000 W metal halide lamps with microprocessor controlled ignition and power to the lamp

• ***LUXEON K2 (Winner of the speciality lamps category)*** Lumileds Lighting releases the LUXEON K2 LED setting new standards with the industry's highest junction temperature, drive current capability, moisture sensitivity level and light output characteristics for maximum engineering and design flexibility.

• ***Ultimate Architectural Floor Tiles (Winner of the speciality luminaires category)*** LightWild brings the entertaining impact of colorful LED lighting to floors, pathways, dance areas, and patios with Ultimate Architectural Floor Tiles. Tiles are weather proof for indoor or outdoor use and controllable with DMX or LightWild software.

• ***Lednium Series*** OPTEK's Lednium Series provides a 10-Watt energy-efficient 3-D packaged that offers up to 330 lumens with 120° viewing angle in amber, blue, green, red, white and RGB.

• ***Thermo T5 High Efficiency and High Output Lamps*** from TotaLight Systems comes the Thermo Extra Long Life T5 lamp with a sealed T8 outer tube for cold climates to -15 ºC, with peak lumens at 5C. The lamps will last 55,000 hours. Total-Light Systems has also developed a cold temperature T8 lamp with a T12 sealed outer bulb for similar conditions and life expectancy.

• ***EFO-Ice™*** Fiberstars EFO-Ice fiber optics replace fluorescent tubes in freezer cases for bright, even illumination, while eliminating heat.

• ***CMH20MR16 lamp (Winner of the lamps category)*** GE's 20-watt Ceramic Metal Halide MR16 lamp with provides precise 12 degree Spot and 25 degree Flood beam control with 960 lumens, 3000 Kelvin color temperature, and 8000 to 12000 hour life. This new CMH lamp would replace--and provide more light than a 50 W halogen MR16. Its lamp life is at least four times longer (12,000 hours versus 3,000 hours or less) and it provides more than four times the efficacy (80 lumen/W versus 19 lumen/W).

• ***Ultimate Thermo Extra Long Life T8 and T5lamps from*** TotaLight Systems comes the Ultimate Thermo T8, featuring extra long life of 60,000 for cold climate applications to

-15 ºC. Thermo Extra Long Life T5 is featuring a 55,000 hour life and nearly 100 lm/W in cold climates to -15 ºC.

• ***MP 575W/V/BT37/UVS/PS*** Venture Lighting's MP 575 W BT37 Uni-Form pulse start lamps provide twice the mean lumens of 400 watt standard metal halides.

• **Daylight Harvesting Control System** (Winner of controls category**)** Encelium's daylight harvesting control system controls every light fixture for switching and dimming in response to multiple photo sensors via the computer. Through advanced algorithms, the Encelium system saves 50-70% of lighting energy cost.

• ***GE Wireless Energy Management System.*** GE Lighting's Wireless Energy Management System is a simple easy-to-use solution for controlling energy usage of up to 5000 fixtures wirelessly throughout a building. The system features an on-site network that links wirelessly to a controller and a facility's electric meter. The system can be managed locally or via a web server that GE maintains for a monthly fee. The company has lined up some pilot installations and is planning a full launch of the product in the fall of 2006.

• ***ThinkWatt - wireless lighting control system.*** Cooper Lighting introduced ThinkWatt--one of the first wireless control systems with the flexibility to be applied throughout a commercial facility, making it easier to retrofit energy-saving controls in the vast population of existing buildings. ThinkWatt uses a wireless Zigbee - protocol mesh network of occupancy sensors and photosensors that can operate with any type of light source--incandescent, high-intensity discharge, CFL, or linear fluorescent. In a mesh network, wireless nodes are linked together to form a self-organizing network. The system is currently being tested at Cooper Lighting's own facilities and should be available for customers before the end of 2006.

Products trends

This year's trade show introduced the public to few noted advancements on:

• ***Smaller, compact size Cermic MH lamps***. Both GE and Osram Sylvania introduced 20 W CMH lamps in the popular PAR30 shape, and Philips recently introduced a 20 W CMH lamp as well. But perhaps the most useful product will be the 20 W CMH unit introduced by GE Lighting in the popular MR16 format.

• ***Wireless control systems***. As described above, more control system that use wireless communication to either establish and operate a network of similar enabled devices or simply replace the sky-rocketing costly copper wires.

• ***Compact fluorescent lamps*** **(CFLs).** The big news in CFLs was the proliferation of a new standard base for CFL fixtures that allows bulbs and fixtures to be interchanged freely. This overcomes a major obstacle for widespread use of CFLs (if you buy a 26 W fixture, you must use a 26 W CFL). To solve this problem, Energy Star worked with manufacturers to develop the GU24 standard. Consumers who purchase fixtures that use GU24 components will be able to change out lamps/ballasts of varying wattage and lumen output to meet their specific lighting needs, making the switch just as easy as it's been to screw in a 60 W incandescent light bulb to replace a 75 W bulb. Both MaxLite and TCP introduced new products with the GU24 base ranging from 9 to 27 W.

• ***LED's.*** No report on Lightfair would be complete without at least a mention of light-emitting diodes (LEDs), so here's that mention--LEDs continue to make inroads in a number of niche applications, but they aren't yet ready, in terms of efficiency and cost, for widespread use in general illumination.

Some statistics from a GE presentation summarize the situation: The market penetration of LEDs in transportation applications such as traffic lights and railroad signals is about 25%, for signage it's about 5% and for general illumination it's less than 2%.

Lightfair 2006 Evaluation

Each year, an independent research firm conducts a post-show study of LFI attendees to find out what they think of the event:

About LFI in general:

• **92%** consider LFI a necessary **“must-see”** event

• **95%** consider LFI the gathering place for the industry

About the LFI Conference:

• **90%** say LFI keeps them informed of what's going on in the industry

• **89%** say they learn something valuable at LFI **every year**

About the LFI Trade Show:

• **96%** say LFI has a high-quality set of exhibitors

• **91%** consider LFI a source **for discovering new trends** in the marketplace

• **88%** consider LFI a place to find **new lighting design ideas**

• **90%** say LFI is the place to see **new, unique, innovative products**

• **90%** consider LFI a place to see a **wide variety** of products

For more details on the highlighted products at LightFair 2001, please visit the following web site: **http://nps.elumit.com/**

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PRO-EFFICIENT COLD & LIGHTING PRODUCTS (PROEFFICIENCY) Intelligent Energy Europe 2004

Project consortium: **ESCAN Spain** (coordinator), **ESV Austria**, **GERTEC Germany**, **KAPE Poland, ISPE Romania**, **SEVERN WYE United Kingdom**

PRO-EFFICIENT COLD & LIGHTING PRODUCTS' overall aim is to promote voluntary integrate initiatives for the most eco-energy efficient products, within different regional scenarios from the European Market including old, new and candidate Member States, through both the implementation of "pilot promoters initiatives" and "pilot consumers' projects/actions", as well as, the monitoring of effectiveness of initiatives and actions developed.

1. Objectives of PROEFFICIENCY

Specific objectives are focused on:

- Stimulation of promoters through "pilot promoters' initiatives" for the most eco-energy-efficient-products.
- To accelerate market transformation towards more eco-energy-efficient COLD & LIGHTING products (Refrigerators, Freezers, Combis appliances and Lighting products for residential and tertiary sector), through implementation of "pilot consumers' projects/actions".
- Monitoring of effectiveness of developed initiatives/actions.
- Giving special visibility to successful initiatives/actions, to motivate organizations to be in the forefront of the market.

2. Description of the work

The work plan have been structured in 8 work packages, with the participation of partners in each one of them, justifying the mentioned participation since each "pilot promoters' initiatives" and "pilot consumer projects/actions" have different development energy-efficient market. The Work Packages (WK) go as follows:

WK1	Coordination. Management. Reporting.
WK2	Common methodology for achieving territorial objectives.
WK3	State of the art for Regional scenarios of efficient cold & lighting products
WK4	Pilot promoters' initiatives: promotion plans in each Region
WK5	Pilot consumers' projects/actions: Lighting and cold projects/actions in each Region.
WK6	Monitoring of effectiveness of initiatives and actions based on adhered organizations information.
WK7	Specific dissemination activities. (Web page, CD-ROM, LOGO, Poster, Conferences and Workshops, Brochures
WK8	Common dissemination activities.

associated technology for household and tertiary sectors have different implementation in the planned scenarios where voluntary "pilot promoters' initiatives" and "pilot consumers' projects/ actions" will be carried out, as well as, the required competition for the implementation of these initiatives and projects.

The methodology used will follow "pilot promoters' initiatives" and "pilot consumers' projects/actions" integrated approach, in which clusters constituted by key actors (manufacturers, importers, retailers, energy agencies) on the promoters side, and (Consumers' Associations, Local/Regional Governments, others) on the consumers' side, will work within an established working framework but adapting to the different realities (market, social, economic) for each region.

The different work-packages (WORK-PLAN) will be carried out at a Region level; the information will be collected at this level and will be consolidated at European level subsequently.

The approach of this project is oriented to overcome the existing barriers[1] in order to accelerate and expand the penetration of new and more efficient products, refrigerators[2] and lighting products, and to integrate instruments from both sides supply and demand:

- On the supply side, "pilot promoters' initiatives" will incorporate promoters, who will work on the Project promotion of energy efficient products; the promoters will elaborate a promotion plan and will implement it.

- On the demand side, "pilot consumers' projects/actions" will incorporate consumers, who will carry out demonstrative pilot projects oriented to electric consumption reduction, and the promoters will support them.

PROEFFICIENCY Project will facilitate the adoption of integrated voluntary approaches related to the production and application of energy efficient products. Methodology basis is directed towards complying with the proposed objectives:

- Clusters will be constituted with the key actors, and some of them will sign an adhesion document, in order to involve them all along the life of project and after it finished, since at the end, the voluntary adhesion for promotion and adoption energy efficient products will continue;

- Awareness activities will be carried out oriented to increase knowledge and commitment of target groups, including meetings, workshops, and conferences oriented to market transformation to most efficient products.

- Demonstrative "pilot promoters' initiatives" and "pilot consumers' projects/ actions" will be carried out in real conditions which will study the market, technical, economical aspects as well as, incentives for the success of these actions. In order to achieve the Project success, the strategy will be to focus the Project on selected scenarios (e.g. one scenario could be an area of Madrid Region), and to focus on special target groups (e.g. Regional Authority, Local Authority, Housing Association, Shopping Associations). If within a scenario appears difficulties, we will select another scenario (e.g. other area in Madrid Region). The selection of scenarios will be in agreement with the target groups who present more

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[1] *One of the main barriers to the penetration of energy efficient equipments and products in the market is lack of costumers' awareness, information and technical knowledge on energy consumption of individual equipment and possible energy saving*

[2] *Refrigerators, freezers and combis.*

involvement in the Project (e.g. in Spain we will select the scenarios in agreement with the Regional Government).

3. Conclusion - expected results

The overall outcome will be increased promotion, acquisition and use of eco-energy efficient COLD & LIGHTING products in different European Regions. Results will be achieved in different ways:

- Stimulated pilot promoters' initiatives for the most eco-energy- efficient products in six EU regions.
- Involving of costumers by implementation of pilot consumers' projects/actions.
- Monitoring of initiatives/actions effectiveness.
- Integrated experiences and transferring knowledge within organizations of old, new and candidate Member States.

The network formed by the project partners and actors who will work coordinated in the Project, will stimulate the adhesion as promoters of the project of new organizations, and specifically, in the scenarios selected through the development of "pilot promoters' initiatives".

Professionals of lighting and cold products, who will be invited to adhere to the Project as promoters, could provide technical assistance, to consumers.

The fact of the countries participation with developed "pilot promoters' initiatives" (Northern Europe) and others less developed (Southern Europe, New Member States) will allow the stimulation of initiatives in both groups possible, since some countries could give experience to others, while at same time they could learn the barriers for developing energy efficiency initiatives from them.

Fundamentally, the consumers (beneficiaries) sign a Project Adhesion Document, and commit themselves to carry out pilot projects/actions by using more efficient products.

Consumers Organizations, Residents Associations, Housing Companies, Local Governments, could buy very energy efficient products for save energy and money.

Demonstrative "pilot consumers' projects/ actions", in real conditions, together with dissemination activities, will encourage the actors' participation and will promote new "pilot projects/ actions" for energy efficient pro-ducts, since they will facilitate marketing and publicity and will serve as an example to be replicated by other potential participants.

The monitoring of initiatives/actions effectiveness in the regional market (refrigerators and lighting) with promoters and consumers' participation will allow future improvement of initiatives and actions. It will have an important effect of more efficient equipments promotion, because they will facilitate increased actors' awareness, information, and technical knowledge on energy consumption of products.

Experiences integration and knowledge exchange, in European representative regions, whose market situation are different, will be important and will offer an opportunity to promote the Project in others regions of the old, new and candidate Member States organizations.

Summarizing, it is expected that 100 European organizations (Promoters, Consumers, and other actors) adhere to project by the signing of a declaration to dedicate efforts to the COLD & LIGHTING energy efficient pro-ducts. Energy saving in lighting improvements should be 2,000,000 kWh/year, which substitute 8000 tones of coal and should avoid 3350 tones CO_2 per year. Similar energy saving should obtain for cold appliances initiatives.

In the short-medium term, the expected results addressed the implementation of different "pilot projects" in different EU countries, with the participation of relevant actors: consumers (Local Authorities, Residents Associations) and promoters (Manufacturers, Importers, Retailers, Energy Agencies, Technicians of involved sectors, Consultancy Companies).

Strategic impact of the proposed Project is related directly first, to the creation of new opportunities for the European energy efficient COLD & LIGHTING products and their applications in the Project's influence area, and afterwards, through replication, to the rest of Europe. This will enhance the competitiveness of European manufacturers of energy efficient products, and the promotion of it in order to achieve great visibility among market actors.

The pilot initiatives and actions of new schemes based in others tested schemes, the inclusion of monitoring (feedback) on relevant framework conditions, as well as the commitment of target groups, will allow generate important synergy within the actors and will contribute to provide a Regional EU impulse to accelerate market transformation towards more efficient COLD & LIGHTING products.

PROEFFICIENCY Project incorporates an important promotion programme oriented to "pilot promoters' initiatives" and "pilot consumers' projects/actions" incorporating European/Local/Regional actors (Manufactures, Importers, Retailers, Energy Agencies, Municipalities, Residents Associations, others). With such activities, the project intends to contribute in the medium and long term with the EU energy objectives: decreasing the energy consumption and energy supply dependence.

Moreover, the knowledge and experience levels will be increased in the regions object of these actions, helping with the improvement of energy service quality and cost savings, since the acquisition of more energy efficient products will result in certain energy and money savings.

The replication of this project could be carried out in other EU regions where there are not experiences about these initiatives and that present favorable conditions to overcome barriers (for instance promoters initiatives present economic incentives for the energy efficiency projects).
(http://www.escansa.com/proefficiency)

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