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Centrul de Ingineria Iluminatului

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International Conference
ILUMINAT
2007
31 May - 1 June, Cluj-Napoca

The 4th International Conference ILUMINAT 2007

PROCEEDINGS

31 May - 1 June 2007
Cluj-Napoca, Romania

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The 4th International Conference ILUMINAT 2007

May 31 - June 1, 2007, Cluj-Napoca, Romania

Additional information of this Conference Proceedings are available from the President of the Organising Committee
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Dear ILUMINAT 2007 participant,

If we want to progress in our field, sharing experience about basic lighting research, applied research and product development is essential. Especially at this moment the lighting world sees some sensational new developments, which we need to discuss about. Many of these developments are on the program of the ILUMINAT Conference. Just a few examples:

Since 1932, when the first gas discharge lamp was introduced, we have coloured our outdoor, nighttime environment a bit yellowish with the efficient sodium gas discharge lamps. Only in 2005 we have seen the introduction of a new kind of metal-halide lamp, specifically developed for road and street lighting. This lamp combines high efficacy, reliable lifetime for the first time with natural white light. This gives totally new possibilities for lighting our night time environment in natural white light.

We talk already more than 10 years about light emitting diodes, but only 2 years ago we have seen the real breakthrough in the use of LEDs for real lighting. This is already changing our conventional lighting very quickly and very drastically. These solid state light sources will become essential in the context of sustainability and fighting global warming and CO2 emissions.

Last but not least the subject "non visual biological effects of lighting" is becoming rapidly a subject important in designing healthy lighting installations.

I am looking forward to learn new things about these and many more subjects during ILUMINAT 2007.

I wish the participants of ILUMINAT 2007 an instructive and enjoyable Conference and I am looking forward to participate in it.

Eindhoven, May 2007

Wout van Bommel

CIE President

Ladies and Gentlemen,
Dear Colleagues,

It is a real pleasure for me to wish you, on behalf of the LEADING BOARD of CNRI (Romanian National Committee on Illumination) a great success to the 4th International Conference ILUMINAT 2007.

This event is organized by the CNRI section of Cluj-Napoca in cooperation with Universitatea Tehnica – Centrul de Ingineria Iluminatului -Technical University of Cluj-Napoca, Lighting Engineering Center -. An important support is assured by the programs IEE-EnERLIn and CEEX – CREFEN and last but not least, by the associated members of CNRI: ENERGOBIT SCHREDER LIGHTING, LUXTEN LIGHTING COMPANY, PHILIPS ROMANIA, OSRAM ROMANIA, ELECTRICA CLUJ section.

I am very proud and satisfied to observe that, from the first edition of this International Conference in 2001, which I initiated, the manifestation developed and knew a continuous progress, thanks to the efforts made by Professor Florin POP, the Cluj team and all those I already mentioned.

The themes/subjects treated by these conferences have an outstanding importance for the correct and modern development of an efficient lighting, from the energetically point of view and able to assure a comfortable, functional and esthetical luminous environment, inside and outside of different types of buildings.

It is important to mention that now for Romania, and not only, the achievement of an urban comfortable luminous environment represents an imperative necessity, a compulsory condition for the circulation security and a high quality esthetic.

Another actual problem having an important impact over the energetically efficiency is represented by the transfer of the natural light in connection with electrical light inside of the buildings, following a permanent and intelligent harmonization between these two components, the aim is focused on the maintenance of the indoors parameters at a constancy level.

In Romania, it was made a great progress concerning the lighting quality and in this progress, the CNRI and the universities were involved in a substantial way, especially by post-graduated (education) courses and by the introduction from 2005 of the CERTIFICATE of PROFESSIONAL COMPETENCE IN LIGHTING (LIGHTING CERTIFICATE).

I consider that the present conference will be a new and happy opportunity to change some ideas and information, which will have an important contribution at the increasing of the efficiency and quality of the luminous environment.

In the same time, this conference has the privilege to be honored with the presence of our very special guests: M. Prof. Ph. D. Wont Van BOMMEL, President of CIE, M. Em. Prof. Ph. D. Ianos SCHANDA, M. Dipl. Eng. Alex. STOCKMAR, President of N.C. Germany, M. Prof. Ph. D. Koichi IKEDA, Japan, Ms. Prof. Ph. D. Lisa HALONEN, Finland.

Let me wish again a special success to the 4th International Conference of Lighting and to address my warm congratulations to the organizing team for all the effects made and for the obtained results.

Prof. Cornel BIANCHI
CNRI President

WELCOME

Ladies and Gentlemen,
Distinguished participants,
Dear friends and colleagues,

On behalf of the Conference Organizing Committee, I would like to welcome you to the opening ceremony of the 4th International Conference ILUMINAT 2007 and to its two days of interesting professional meetings and social events.

The Conference is honored by the presence of national lighting schools from worldwide. Interesting scientific papers were submitted both by research teams or professionals from abroad and from national universities and companies – Bucharest, Cluj, Craiova, Iassy, Timisoara, Tg. Mureş: 44 papers on 7 sessions, with 75 authors. Unfortunately, some of them are not able to participate, due to different personal or professional reasons. The registered participants, authors or auditory, will contribute to a high level of the conference. The topics of the presented research cover the entire field of Light & Lighting – Interior and exterior luminous environment, Energy efficient actions and solutions, Command and control of lighting systems, Photometric parameters, Computer programs, Electrical supply of lighting installations, and Architectural space. The participation of young researchers contributes to the success of the conference and to the improvement of their knowledge.

A special contribution is offered by the participation of the research team from LAEL – Light & Architectural Environment Laboratory from Korea. Professor Jeong Tai KIM initiated a strong cooperation between our Lighting Laboratories, in 2003, by The Memorandum of Understanding between Light & Architectural Environment Laboratory, Kyung Hee University, Korea and Lighting Engineering Center, Universitatea Tehnica din Cluj-Napoca, Romania.

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: EnERLIn – European efficient residential lighting initiative, an EIE – SAVE program to promote Compact Fluorescent Lamps in the residential sector, and CREFEN – Integrated software system for energy efficiency and saving in residential sector, a Romanian CEEX program. Reports on the dedicated work under the frame of these programs will be submitted.

The two-day conference includes invited lectures where key representatives and high specialists will present their views, programs and research to advance energy efficiency in lighting. Dedicated sessions on specific themes and topics will permit in-depth discussions among participants. The conference allows 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.

We may consider our ILUMINAT 2007 Conference an interesting and useful FORUM of international lighting community. Some members of the Scientific Board expressed their deep regrets for not being able to attend the conference, wishing the participants great success.

Many thanks and gratitude to the members of the Honorary, Scientific and Organising Committees,Conference Secretariat, to the Sponsors financial support and to the boarding staff of the Conference.

It is our pleasure to invite you all to join the next 5th International Conference ILUMINAT 2009, to be held in Cluj-Napoca, the heart of Transylvania, on April 2009.

Wishing to realize the promotion of the lighting knowledge, to provide developments in lighting field, to enhance our friendship relations, I would like to welcome to all of you, hoping that you will remain with enjoyable memories of stimulating days in Romania.

Dr. Florin POP, Professor
President of the Organizing Committee
Vice-president of the Romanian National Committee on Illumination

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SUBJECTIVE IMAGES OF NIGHTSCAPES IN DOWNTOWN SEOUL

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ABSTRACT

Seoul, as one of the largest cities in East Asia, boasts lively night scenes. Colorful neon signs and outdoor lights are leading components of its night scenes. For this study, slides were made of street scenes at four locations that characteristically show the city's night scenes. A survey was also carried out for the analysis of people's subjective responses to the images of urban night streetscapes. For analysis of the result of the survey, the SPSS 10.0 statistical program was used along with statistical techniques, such as frequency analysis, factor analysis, correlation analysis, and variance analysis. According to the results of the study, Night Streetscape-4 (of a commercial and business district) shows lively and interesting images, while Night Streetscape-1 (of high-rise buildings in the shopping district, where landscape lighting is provided) displays beautiful and harmonious images. As a result of factor analysis, harmony and liveliness were selected as representative factors. Variables related to arrangement appear to have the closest correlation to those related to harmony. With the exception of variables related to warmness, all variables indicate difference of median values in night streetscape, while those related to beauty indicate the largest difference of median value.

Keywords: Subjective images, Questionnaire survey, Night streetscapes

1 INTRODUCTION

1.1 Purpose of Research

There has been a high level of interest in urban night streetscape. Local governments are among those that show such an interest. They seek commercial and cultural effects with landscape lighting on buildings and bridges, often using them as tourism attractions. However, such an attempt sometimes does damage to the overall harmony of the nighttime urban landscape as a result of focusing only on the esthetic quality of the illuminated structures. This study aims to analyze the subjective responses of people to the images of night streetscapes, in order to use the results for future design of downtown nightscape.

1.2 Scope and Method of Research

The images of night urban streetscapes are analyzed in this study. Urban streetscapes contain representative components of night landscapes. The components of night landscapes covered in this study include street lamps, commercial signboards, electric bulletin boards, illuminated buildings, trees and neon signs, light from building windows, vehicle headlights, the surface of roads and sidewalks, and the windows or walls of unlighted buildings.

A preliminary survey was conducted of major streets in Seoul. The preliminary survey was performed on the streets, including main thoroughfares and backstreets in commercial districts, where pedestrians can see the aforesaid components of night landscapes. The process included taking photographs of the components and checking the spots from which one can have a look at the entire street. (Inclusion of backstreets in commercial districts in this study was based on the judgment that their night landscape is more affected by such factors as the brightness, size or shape of commercial signboards than main thoroughfares. However, backstreets have limitations for the purpose of this study, as they do not properly contain the images of representative night urban streetscape, including a multitude of pedestrians, various large-sized buildings, light from moving vehicles and streetlamps. Thus, they were excluded from the main study carried out later.) Night landscapes were also photographed from a car stopped at a traffic signal to grasp the images felt by vehicle drivers.

Through the preliminary survey, samples were selected of the streets to be included in the study. For the selection, Seoul was divided into two sectors: Gangbook, the sector located on the north side of the Han River, and Gangnam, the sector located south of the river. The former has a longer history of regional development than the other. Two streets in Gangbook and Gangnam, respectively, were selected for the study. Consideration was given to the need to include low/high building areas, intersections and commercial areas to see different nightscapes.

Photographs of nightscapes were taken using a digital camera in similar conditions from 8:00 pm to 11:00 pm (on the same day), the time of the evening that people view the most representative street nightscapes on their way home after work. Four of them were finally selected in discussion with architecture majors. For the appraisal, survey questionnaires were given to 44 undergraduate students from the Department of Architectural Engineering in Kyung Hee University. Of those, 39 responded with valid answer sheets. A dark adaptation period was given to them before the survey questionnaires for the appraisal of subjective responses. A brief explanatory session was provided concerning the photos, prior to the survey questionnaire. SD Scaling was used as a tool to measure subjective responses. For statistical analysis, the SPSS 10.0 Statistical Program was used and frequency, factor, correlation, and variance analyses were carried out.

2 SITUATION OF NIGHT STREETSCAPES SUBJECTED TO EVALUATION

2.1 Status of Night Streetscape-1 (A night streetscape of a high-rise building for which exterior lighting is provided)

Night Streetscape-1 was photographed at a pedestrian's eye level (if the pedestrian was standing on a curb). High-rise buildings, including a cinema and a department store, appear as major landscape elements. The walls of the cinema are flooded with up light. Indoor lighting in the staircases of the buildings and the inner walls of the buildings are visible through transparent windows. The lower ends of the buildings display dazzling nightscapes with lights radiated from street lamps mixed with lights from indoors. Other nightscape elements include trees lining the street, vehicle headlights, neon signs and commercial signboard lights. In Night Streetscape-1, roadside high-rise commercial buildings are chief landscape images.

Figure 1 Night streetscape-1

Figure 2 Night streetscape-2

2.2 Status of Night Streetscape-2 (A night streetscape of a commercial district composed of low-rise buildings)

Night Streetscape-2 was photographed at a pedestrian's eye level (if the pedestrian was standing on a curb). Lighting for commercial signboards at lower sections of commercial buildings, trees lining the street, electric signboards on top of the buildings and the leisurely street, appear as major landscape elements. In addition, letters of various colors in signboards appear on higher ends of the five-story commercial building. Lights radiated from streetlamps onto trees lining the street, vehicle headlights and the paved surface of the street appear as ancillary landscape elements. Overall, dominant images are the leisurely street and the lights on the roadside commercial buildings.

2.3 Status of Night Streetscape-3 (A night streetscape of electric signboards at an intersection and unlighted buildings)

Night Streetscape-3 was photographed at a pedestrian's eye level near an intersection. Electric signboards on upper sections of buildings, signboards on roadside buildings, unlighted high-rise buildings and the figures of moving cars (taken from behind) appear as major landscape elements. In addition, the light from streetlamps and the surface of the street are shown. Moving cars on the street and lighting on signboards on commercial buildings appear as major landscape images.


Figure 3 Night streetscape-3


Figure 4 Night streetscape-4

2.4 Status of Night Streetscape-4 (A night streetscape of a commercial and business district)
Night Streetscape-4 was photographed at a pedestrian's eye level at the entrance to Gangnam Street. Brightly-lit signboards of commercial buildings and electric ad signboards on upper sections of buildings appear as major landscape elements. In addition, moving cars on the street, streetlamps and trees lining the street appear as street landscape elements. Signboards on roadside buildings, vehicles driving on the street and brightly lit commercial signboards appear as major landscape images.

3 ANALYSIS OF SUBJECTIVE RESPONSES

3.1 Overview of Survey Questionnaires

1) Composition of questionnaires and reliability analysis
Ten words were finally selected out of 40 chosen ones from existing research for appraisal of subjective responses to the images of the night streetscapes. A questionnaire was composed of two general questions and ten questions about subjective feelings regarding the images of night streetscapes. For an appraisal measure, a five-stage SD Scaling was used. Reliability analysis was made of the words contained in the questionnaires. The reliability analysis based on Cronbach's α showed that the value of Alpha stood at 0.7632, meaning that all the ten questionnaires have inner reliability.
2) General
Concerning 39 valid questionnaire sheets, the subjects were divided into three age groups: those aged 22 and 23 (5 people or 12.9%), 24 to 26 (31 people or 79.4%) and 27 (3 people or 7.7%). 33 people or 84.6% of them were males and the other six or 15.4% were females.

Table 1. Questions

Concerning	Questions
Age and gender	How old are you? Are you a man or a woman?
Night image	Do you think that this night streetscape is beautiful (or ugly)?
	Do you think that this night streetscape is pleasantly bright (or dark)?
	Do you think that this night streetscape leaves an impression of orderliness (or slovenliness)?
	Do you think that this night streetscape feels cold (or warm)?
	Do you think that this night streetscape leaves an impression of liveliness (or calmness)?
	Do you think that this night streetscape is interesting (or dull)?
	Do you think that this night streetscape is complex (or simplistic)?
	Do you think that this night streetscape leaves an impression of splendidness (or plainness)?
	Do you think that this night streetscape leaves an impression of harmony (or disharmony)?
	Do you think that this night streetscape seems clear-cut (or hazy)?

3.2 Mean Values of Subjective Responses

The result of frequency analysis of subjective responses to the various shapes of the night streetscape images is shown in Figure-5. In items appraising their quality of being lively-calm, interesting-dull, complex-simple, splendid-plain or clear-cut - hazy, Night Streetscape-4 appears to be more favored than the others, followed by night Streetscape-1, -3 and -2. It is judged that Night Streetscape-4 attracts the most conspicuous subjective responses with its many colorful commercial signboards on roadside buildings. Night Streetscape-1 shows the highest mean value among the four in beauty and harmoniousness, with lighted high-rise buildings appearing as a major landscape element, but the lowest mean value in warmness.

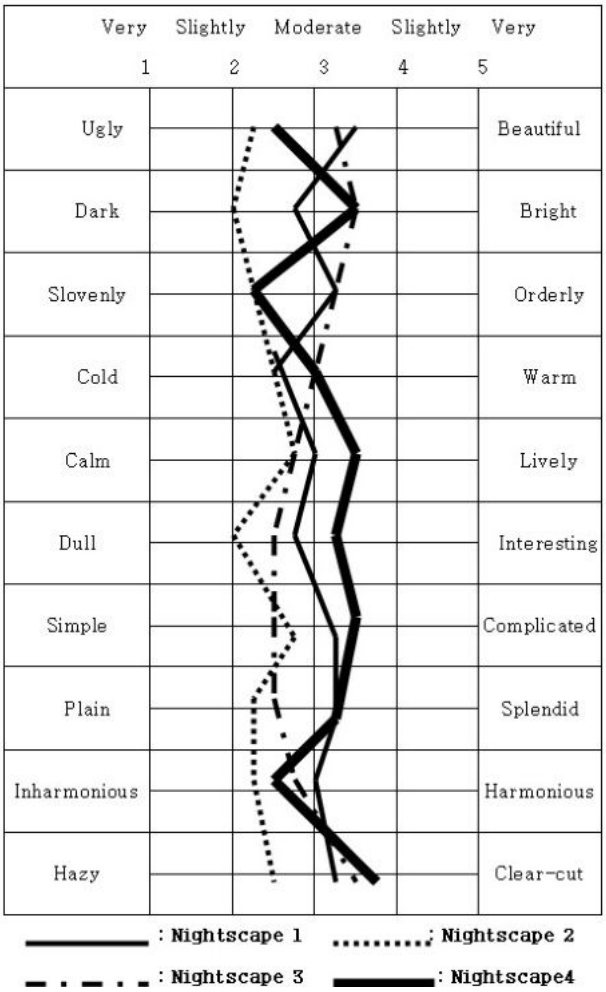

Figure 5 Mean value of responses

3.3 Analysis of Night Streetscape Elements

The result of the analysis of factors related to the night streetscapes is shown in Tables-2 through 5. As for Night Streetscape-1 (a night streetscape of a high-rise building for which landscape lighting is provided), Factor-1 was named “the beauty of the night landscape” as it is associated with harmoniousness, beauty and splendid. Factor-2 was named “liveliness” as it is associated with brightness, liveliness, and the quality of being clear-cut. Factor-3 remained unnamed as it shows low reliability, though it is associated with orderliness and warmness. Factor-4 was named “the diversity of night streetscape” in consideration of its association with complexity and the quality of being interesting.

Concerning Night Streetscape-2 (a night streetscape of a commercial district composed of low-rise buildings), Factor-1 was named “the liveliness of night streetscape,” based on its association with the qualities of being clear-cut, interesting, lively and warm. Factor-2 was named “harmoniousness” as it is associated with orderliness and harmoniousness. Factor-3 remained unnamed as it shows low reliability, though it is associated with beauty, brightness and complexity.

Table 2. Factor analysis on night streetscape 1

Factors·	Variables	Components			
		Factor 1	Factor2	Factor3	Factor4
Beauty	Harmonious	.817	-5.811E-03	6.616E-02	9.327E-02
	Beautiful	.783	4.700E-02	9.494E-02	-.261
	Splendid	.628	3.374E-02	-.275	.474
Liveliness	Bright	5.500E-02	.844	4.227E-02	.162
	Clear	.256	.763	.337	-5.763E-02
	Lively	-.174	.657	-.150	-.160
	Orderly	.253	-6.014E-02	-.827	-.177
	Warm	.345	2.804E-02	.777	-.148
Diversity	Complicated	-.288	-.112	-.112	.797
	Interesting	.344	9.245E-02	.322	.739
Cronbach Alpha		.5812	.6763	.1146	.6061
Eigen values		2.160	1.754	1.631	1.591
% of Variance		21.596	17.543	16.313	15.911
Total explained of variance(%)		71.364			

Table 3. Factor analysis on night streetscape 2

Factors	Variables	Components		
		Factor 1	Factor 2	Factor 3
Liveliness	Clear	.758	5.133E-0	-4.530E-0
	Interesting	.718	3.762E-0	.289
	Lively	.636	-.124	.246
	Splendid	.557	-.458	.179
	Warm	.487	.440	-.407
Harmony	Orderly	-7.906E-0	.858	.268
	Harmonious	3.546E-0	.815	2.157E-0
	Beautiful	-7.644E-0	.321	.774
	Bright	.396	.160	.674
	Complicated	.248	-.313	.626
Cronbach Alpha		.6880	.6747	.4799
Eigen values		2.269	2.049	1.860
% of Variance (%)		22.686	20.492	18.602
Total explained of variance (%)		61.780		

Table 4. Factor analysis on night streetscape 3

Factors	Variables	Components		
		Factor 1	Factor 2	Factor 3
Harmony	Harmonious	.810	.186	-.365
	Beautiful	.724	-8.660E-02	-2.044E-02
	Orderly	.694	-.156	.230
	Clear	.685	.299	.210
	Interesting	.594	.590	.123
	Splendid	1.905E-02	.742	.371
	Warm	.351	-.580	7.570E-02
	Complicated	.177	.567	-8.264E-02
Liveliness	Lively	-.104	.309	.768
	Bright	.380	-.314	.663
Cronbach Alpha		.7342	.3215	.5594
Eigen values		2.795	1.906	1.425
% of Variance (%)		27.953	19.063	14.252
Total explained of variance (%)		61.268		

Table 5. Factor analysis on night streetscape 4

Factors	Variables	Components		
		Factor 1	Factor 2	Factor 3
Splendidness	Complicated	.785	-.127	9.851E-02
	Bright	.778	.130	.140
	Splendid	.762	.312	.173
	Clear	.739	.443	-.224
	Interesting	.702	.247	.249
Harmony	Harmonious	.140	.905	-5.438E-02
	Orderly	5.863E-03	.819	.109
	Beautiful	.232	.717	.142
	Warm	.105	.182	.899
	Lively	.570	-.104	.586
Cronbach Alpha		.7466	.7466	.1745
Eigen values		3.250	2.436	1.358
% of Variance (%)		32.497	24.356	13.578
Total explained of variance(%)		70.431		

Turning to Night Streetscape-3 (a night streetscape of electric signboards at an intersection and unlighted buildings), Factor-1 was named "beauty" as it is associated with the qualities of harmoniousness, beauty, orderliness and being clear-cut and interesting.

Factor-2 remained unnamed due to its low reliability, though it is associated with splendidness, warmness and complexity. Factor-3 was named "liveliness" as it is associated with liveliness and brightness, despite the low Cronbach's coefficient value (0.6 or lower).

About Night Streetscape-4 (a night streetscape of a commercial and business district), Factor-1 was named "Splendid," based on its association with complexity, brightness, splendid, and being clear-cut and interesting. Factor-2 was named "harmoniousness," as it is associated with harmoniousness, orderliness and beauty. Factor-3 remained unnamed due to its very low reliability, though it is associated with warmness and liveliness.

As shown in the foregoing, factors associated with the images of night streetscapes were harmoniousness and liveliness. Factor loading, which refers to the level of correlation between each factor and variables, stood at not lower than ± 0.5 in the factor analysis related to the entire night streetscape, showing a very high significance.

For the entire streetscapes, the KMO stood at .529 to .744 and the significance level of the value of Bartlett's Test of sphericity at 0.000, showing the propriety of the factor analysis. The explanatory power concerning the night streetscapes based on extracted factors stood at approx. 71% (for Night Streetscape-1), about 61% (Night Streetscape-2), about 61% (Night Streetscape-3) and about 70% (Night Streetscape-4), respectively.

3.4 Major Factors Affecting Images of Night Streetscapes

1) Night Streetscape-1

Correlation analysis was carried out to extract major variables affecting the images of the night streetscapes. The analysis shows that variables, such as dark-bright and clear-cut-hazy, remain at a higher level of correlation (r=.595) than the others, within the significance level of 0.01, followed by ugly-beautiful and harmonious-inharmonious (r=.503). The brighter the night streetscape was, the more clear-cut the image of subjective responses was. The better harmonized the components of a night streetscape was, the more beautiful an impression they left. Within the significance level of 0.05, variables, such as dull-interesting and plain-splendid shows the highest correlation (r=.402) in comparison with the other variables. Variables, such as disarranged-arranged and cold-warm, shows a negative correlation (r= -.389), showing that variables associated with warmness leaves an impression of slovenliness.

2) Night Streetscape-2

In major variables affecting the night streetscape of a commercial district composed of low-rise buildings, variables, such as slovenly-orderly and inharmonious-harmonious, showed higher correlation (r=.631) than the other variables, within the significance level of 0.01 , followed by calm-lively and dull-interesting (r=.483), indicating that the higher the image of orderliness the night streetscape shows, the higher the impression of harmoniousness it leaves. A lively night streetscape appears to leave an impression of "interesting." Within the significance level of 0.05, dark-bright and simple-complex show higher correlation (r= .400) than other variables.

3) Night Streetscape-3

Concerning Night Streetscape-3, inharmonious-harmonious and hazy-clear-cut showed the highest correlation (r=.538), within the significance level of 0.01 , followed by dull-interesting and inharmonious-harmonious (r=.524), indicating that the higher the image of being clear-cut the night streetscape shows, the higher the impression of harmoniousness it leaves, and that the more harmonious the components of the night streetscape are, the more interesting image they leave. With the significance level of 0.05, calm-lively and plain-splendid show higher correlation (r= .394) correlation than other variables.

4) Night Streetscape-4

Correlation analysis was carried out for extraction of major variables affecting the images of Night Streetscape-4. Slovenly-orderly and inharmonious-harmonious indicated the highest correlation (r= .664) within the significance level of 0.01, showing that the more orderly images of the components of the street landscape are, the stronger the harmonious impression they leave as in Night Streetscape-2. Dull-interesting and plain-splendid also showed high correlation (r=.524), indicating that the stronger the splendid image of a night streetscape is, the more interesting impression it leaves. Within the significance level of 0.05, inharmonious-harmonious and hazy-clear-cut showed the highest correlations (r= .472) among variables. (Table-9)

3.5 ANOVA Analysis of Night Streetscapes

ANOVA analysis was carried out to see whether there is a difference in the images of the night streetscapes. It appears that subjective responses to the night streetscapes showed a significant difference in the mean value of the image from each other in all variables except cold-warm. (Table 6) The mean square value between groups (12.66) appeared to be considerably higher than the mean value within groups (.419), indicating that there is a difference in the mean value in subjective responses to the images of night streetscapes. Also, the F value (30.21) was much higher than F threshold value (3.78), thus rejecting the null hypothesis to the effect that night streetscapes have little difference between median values. This is confirmed by the low level of significance (0.000 〈0.05).

Table 6. ANOVA analysis of images of night streetscapes

		Sum of Squares	df	Mean Square	F	Sig.	F threshold value
Beauty	Between Groups	37.974	3	12.658	30.208	.000	3.78
	Within Groups	63.692	152	.419			
	Total	101.667	155				
Brightness	Between Groups	37.455	3	12.485	19.928	.000	3.78
	Within Groups	95.231	152	.627			
	Total	132.686	155				
Arrangement	Between Groups	27.660	3	9.220	12.222	.000	3.78
	Within Groups	114.667	152	.754			
	Total	142.327	155				
Warmness	Between Groups	2.205	3	.735	1.195	.314	3.78
	Within Groups	93.487	152	.615			
	Total	95.692	155				
Liveliness	Between Groups	15.231	3	5.077	7.983	.000	3.78
	Within Groups	96.667	152	.636			
	Total	111.897	155				
Interest	Between Groups	31.513	3	10.504	15.474	.000	3.78
	Within Groups	103.179	152	.679			
	Total	134.692	155				
Complexity	Between Groups	18.513	3	6.171	6.452	.000	3.78
	Within Groups	145.385	152	.956			
	Total	163.897	155				
splendidness	Between Groups	27.923	3	9.308	14.589	.000	3.78
	Within Groups	96.974	152	.638			
	Total	124.897	155				
Harmony	Between Groups	15.410	3	5.137	5.917	.001	3.78
	Within Groups	131.949	152	.868			
	Total	147.359	155				
Clearness	Between Groups	16.788	3	5.596	7.227	.000	3.78
	Within Groups	117.692	152	.774			
	Total	134.481	155				

The F value is arrived at by having the mean square value between groups divided by the mean square value within groups. The higher the F value is, the higher the possibility of rejecting the aforesaid null hypothesis, and the larger difference in median values of the night streetscapes. As a result of the ANOVA analysis concerning the F value, variables associated with beauty appeared to be the largest, followed by brightness (19.93), interest (15.47), splendidness (14.59), orderliness (12.22), liveliness (7.98), “clear-cut” (7.23), complexity (6.45), harmoniousness (5.92) and warmness (1.12). Detailed results of the ANOVA analysis are shown in Table-6.

4 CONCLUSIONS

In the profile analysis of subjective responses to the images of urban night streetscapes, Night Streetscape-4 earned high scores in variables, such as liveliness, splendidness, complexity and qualities of being interesting and clear-cut, supposedly on the back of a large number of neon signs associated with the bright and lively night image. Night Streetscape-1 stood out among the four with its beautiful and harmonious image. This shows that a beautiful night streetscape is more properly displayed by exterior lighting on buildings, rather than by the luminance of commercial signboards. Night Streetscape-2 shows more ugly, dark, plain and dull images than the other four.

As a result of factor analysis of the images of night streetscapes, the following factors were extracted: *beauty, liveliness and diversity* from Night Streetscape-1; *liveliness and harmoniousness* from Night Streetscape-2; h*armoniousness and liveliness* from Night Streetscape-3; and h*armoniousness and splendidness* from Night Streetscape-4. It appears that variables concerning the images of the night streetscapes are named their factors. Among variables having an impact on the images of the night streetscapes, orderliness and harmoniousness showed the highest correlations (Night Streetscapes 2 and 4), followed by brightness and being clear-cut (Night Streetscape-1).

It appears that subjective responses to the night streetscapes showed a significant difference in the mean value of the image from each other in all variables except cold-warm. The mean value of the image concerning beauty showed the largest difference among the night streetscapes.

The research shows that Koreans generally tend to focus on the orderliness and harmoniousness of illuminant elements, such as commercial signboards, buildings and streetlamps, in sensing the image of night streetscapes, and that exterior lighting of buildings is a very important element in the outward appearance of a city. It also shows that Koreans have a dim view of dark night streetscapes.

This study attempted to make an analysis of people's subjective responses to urban night streetscapes. However, it lacked a sufficient number of diverse night streetscape images. It would have been a more useful study, if a more diversified and deeper approach had been made with the use of the technique of manipulating the images.

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CREFEN – AN INFORMATIC SYSTEM FOR ENERGY EFFICIENCY IN RESIDENTIAL SECTOR

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ABSTRACT

Both in the European Union countries and in Romania the residential sector represents a very important potential for reducing the energy consumption by introducing some efficient non-pollutant technologies and an advanced energy management. The aim of CREFEN project is to achieve, at the current level of the European researches in the filed, an integrated software system for assessing, prognosis and training the specialist and consumers for the efficient use of the electricity in houses. The system integrates the economical, 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.

1 INTRODUCTION

The electricity consumption in domestic sector has a continual tendency of increasing at the international level. In Romania, this consumption reaches 8.2 TWh in 2003, that represents 22% of the final energy consumption. The consumption per habitant has reduced values (356 kWh/habitant comparatively with 1600 kWh/habitant - the medium consumption for the 25 EU member states), so that the tendency of growing will continue and increase. It is essential that this increasing to be achieved in terms of efficiency.

The European Commission has launched the programs SAVE and "Intelligent energy for Europe" having the objective of promoting the energy efficiency in all sectors, including residential sector. Two important documents: "Green Paper on Energy Efficiency or doing more with less" and "Green Paper on European Strategy for Sustainable, Competitive and Secure Energy" have also been adopted.

Romania was a partner in European projects focused on the energy efficiency promotion within the PHARE, SAVE and ALTENER programs.

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 millions tones of the total final consumers; it means more than 50%. This potential can be capitalized by the improvement of lighting systems and of the electric domestic appliances. The EU Directives related with the labeling of the energy parameters for many electric appliances have been used in order to be implemented in the Romanian legislation.

The Government 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 greenhouse gases emission, in accordance with the features of the National Plan for the Allocation of the Emission Quotas, the development of the National Plan for the Climatic Changes Action, the improvement of the energy efficiency and the promotion of the renewable energy sources.

2 OBJECTIVES OF THE CREFEN PROJECT

The problems to be solved deal with energy efficiency and saving energy field:

- Drawing up of scenarios and prognosis of electricity consumption in residential sector;
- Achievement of an advanced modeling and simulation software system-tool of electricity 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 electricity 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;
- Design and implementation of the software for an interactive system and an electronic book.

The CREFEN 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 to assist and influence the people decision in selecting the households appliances from the other side, that leading to sustainable environment management.

3 METHODOLOGY AND SOFTWARE

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 in the field of energy efficiency used in order to influence the consumers' options in selecting energy efficient appliances for environmental protection by reducing the CO_2 emissions. The scientific knowledge in the field (algorithms for calculation of energy consumption, IT technologies) is connected with technical aspects concerning its implementation as a web-based application containing in its database the most of the technical features of domestic and lighting appliances available in Romania.

The Application is complex both by its multidisciplinary and proposed IT solution. The accessibility will be solved by using web-based solutions. The user needs only a browser in order to be connected to the system without other specific applications. It is also possible to use public terminals with touch screens. The proposed software system will include a complex of interconnected databases, a software system for the management of these data and a system for accessing them via Internet. The most recent platforms and software products for developing the Internet-based applications with databases will be used. The application architecture is a modular one, with the possibility of its extension.

4 RESULTS AFTER THE FIRST YEAR OF THE PROJECT

4.1 Analysis of the energy consumption in the residential sector

The energy consumption in the residential sector was analysed in Romania through a people survey. An European study signaled that promoting energy efficient appliances may lead in Romania to 0.4 TWh/year savings in the electricity consumption. The domestic and lighting appliances are the major energy consumers in a dwelling. Therefore, the actions for home energy saving are directed to them.

The statistic data for the period 2000 – 2004 allow us to determine the variation of total household consumption, total number of household consumers, average consumption per household consumer; the specific household consumption kWh/m^2 per year is presented in Figure 1.

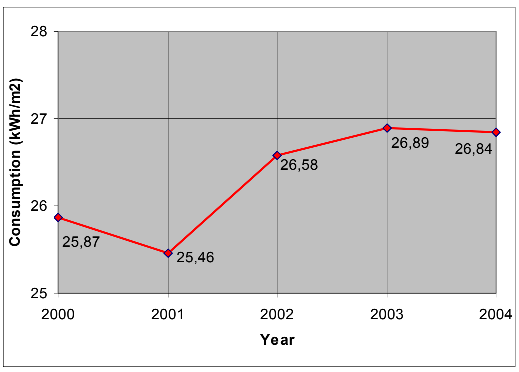

Figure 1 Household consumption per m^2 in Romania - [5]

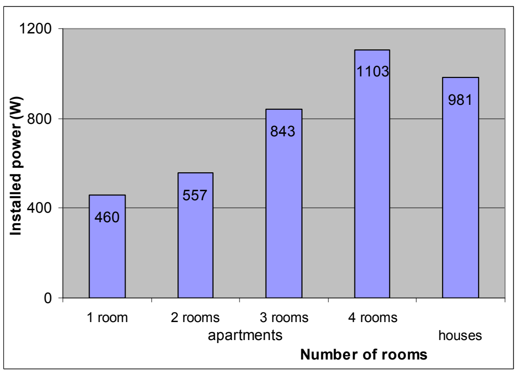

Figure 2 Average installed power in residential lighting - [5]

A preliminary study has been realized on the CREFEN project using feed-back reply forms concerning the usage degree of different household appliances, during November 2005. We were also interested in the GSL and CFLs use in households in Western Romania. We received 295 replies, namely 220 apartments and 75 houses. The equipping degree with CFLs is approximately two units per household. The average installed power in residential lighting is presented in Figure 2.

The analysis of the presented data allows us to estimate a few characteristics of electric energy consumption of households. The annual electric lighting household consumption in Romania in 2004 was about 6.71 kWh/m^2/year (based on the average consumption of 1003 kWh/household/year, the average household surface of 37.39 m^2 and the average contribution of the consumption on the lighting circuits - by 25% according to the study [3]).

4.2 Evaluation and prognosis of the electricity consumption

After analysis of *different models for electricity consumption evaluation and prognosis* (econometric, time series), it is suggested a bottom-up approach, starting from the consumption of appliances and lighting in dwellings.

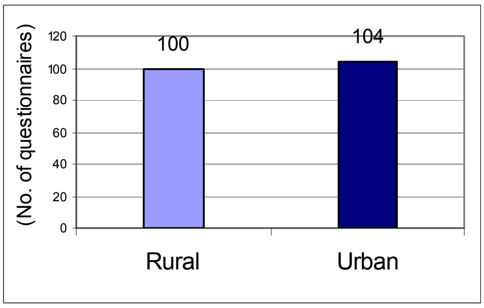

Figure 3 Distribution of questionnaires according the rural or urban area

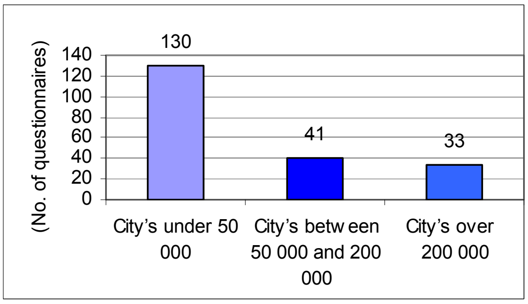

Figure 4 Distribution of questionnaires according the size of localities

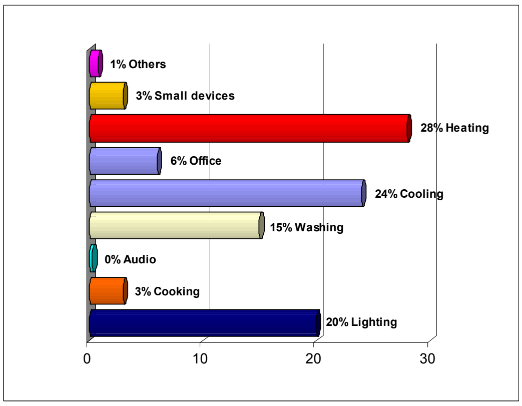

Figure 5 Consumption of household appliances

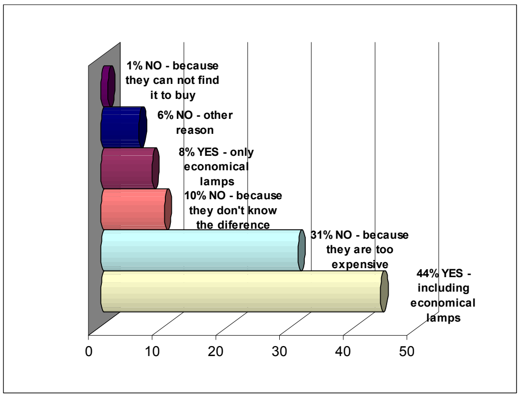

Figure 6 Motivation of CFLs use

The aggregated electricity demand is:

Electricity demand = Σ Ownership x Dwellings x Device consumption

The primary data are to be obtained by questionnaires, acquiring information as: ownership rate for each appliance, rated power, average operation period and others (efficiency, resources consumption). The households distribution is made according criteria as: geographic site, rural or urban environment, family income, dwelling size.

A *Questionnaire Summer 2006 campaign* was achieved [1]. A total of 204 questionnaires were obtained from a large geographical area (see Figures 3 and 4). The first obtained data regards the attitude of the questioned people to the energy efficient domestic appliances topic - more than 70% agree that the decision to buy an appliance should be based on energy efficiency class as well. The consumption in the household utilities is presented in the Figure 5. The motivation of the CFLs use is presented in Figure 6.

4.3 CREFEN web-based application

CREFEN *web-based application* is designed and will be implemented with the goal of enabling European citizens to access, via the Internet, energy and performance information for 12 household appliances sold in Romania. The system is based on information contained within the Energy Label and its associated Sheet.

The three-layered architecture was chosen. The presentation layer assumes that the user only needs a web browser to access all applications provided within the system. The second layer encompasses the server layer – both www server preparing documents for the presentation layer and server realizing authentication, authorization and ensuring integration with data layer. The data layer is a repository of all kinds of data gathered by the system. The database are included in the third layer.

The application is designed to perform the data supply and application layer onto the server side in the backend. Only the presentation is left over to the client computer. The clients will use a traditional web browser requesting the dynamic ASP pages over the server.

The database includes white goods appliances currently stocked by the manufacturers or by the retailers, energy efficient models manufactured by the suppliers of Romania, consumer electronics and office equipment and appliance groups which have recently been labelled such as ovens, lamps and room air conditioners.

The main functions of the web-based application are:

1. *The Web-Interface for Data Acquisition* can be accessed for the users on the base of an ID and a password. After the authentication, the authorized user can choose here one of the web forms designed for data acquisition, specifically for each electrical appliance: fridge/two doors deep freezer, fridge/one door deep freezer, fridges, chest freezer, upright freezer, washing machine, washer drier, tumble drier, dishwasher, air conditioner, oven, luminaire (lamp). After the addition of equipment characteristics, the user can introduce data in the same form or go back to the web-page for choosing of another form. The validation of the data included in the web form is made function of the type of the fields.

2. Selecting energy efficient appliances: The EU label and fiche allows one to select a model in terms of its characteristics such as size or volume, performance, energy and water usage. This information is stored in a database which can be consulted once you have defined your specific needs. The search mechanism in the database is perhaps the most useful service. Searching can use one or more criteria:

- Appliance selection criteria in terms of: Type, Size, Performance and Price Range. These parameters narrow the resulting set of appliances. Some useful hints help the user and assist selection.
- Manufacturer: useful when searching for the whole group of an appliance of one manufacturer.
- Product name: used when searching for a specific appliance.

3. *Database outputs*: Based on the searching parameters, the search mechanism generates a list of matching appliances along with all the data set that is stored in the database. The search output is listed in tabular form containing groups of 5 products plus the typical 10 years old model. For each appliance the following general information is provided: manufacturer/model, size, energy efficiency class, energy consumption and some specific information characterizing a group of appliances. The models are listed in order of lowest to highest energy consumption. The user has to select at least one product to see Lifetime Costs and Savings.

4. *Lifetime cost*: The lifetime cost is calculated based on usage of electricity, water and detergent (where applicable) and compared with the operating cost of a typical 10 year old appliance. This indicates how much energy and money you can save with a new appliance and what contribution this will reduce greenhouse gas emissions. This module is perhaps the most important of the system because it offers information about the energy efficiency of the appliance based on a 15 years lifetime. The user can see both lifetime savings financial and lifetime savings CO_2. Energy efficient appliances have a lower running cost because they have been designed to use electricity, water and detergent more effectively [2, 4]. This lower running cost can offset part or all of the higher initial cost. The comparison is made not only between the 5 products presented on the screen, but also with a typical 10 years old model. The user can then obtain detailed information about a specific model.

5 CONCLUSIONS

Electricity saving through the change of the consumers' behaviour represents a priority both at EU and at national level. The project fits perfectly in the politics concerning the reducing the energetic intensity and the greenhouse emissions in Romania and in Europe. Any action at the level of the electricity consumers will be found in important savings of the fossil combustibles. Under the circumstances of the increase of the primary energy tariffs, the actions of energy saving at the final consumers' level have great chances of success. A monetary unit invested for the realization of this project can finally lead at savings in primary resources consumption quantified between 5 to 10 monetary units. The economical efficiency of the funds utilization is certain and leads to fast money recovery.

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IMPACTUL ADERĂRII LA UNIUNEA EUROPEANĂ ASUPRA PROIECTANȚIILOR DE SISTEME DE ILUMINAT DIN ROMANIA

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La fel ca multe alte domenii de activitate, iluminatul a parcurs o etapă de tranziție de la perioada comunistă până la integrarea europeană şi anumite aspecte sunt caracteristice pentru România.

Sistemul autarhic dinainte de 1989 şi-a spus cuvântul asupra mentalităților: existența unui singur producător important, a instituților mari de proiectare, nererespectarea normelor valabile în acea perioadă şi nu în ultimul rând lipsa unei educații adecvate în domeniul iluminatului în şcoliile de arhitectură au condus la efecte resimțite până în ziua de azi.

La ora actuală, piața sistemelor de iluminat este extrem de dinamică, cu foarte mulți jucători noi şi în continuă schimbare, iar proiectantii sistemelor de iluminat trebuie să se adapteze la cerințele normelor UE şi la concurența din acest domeniu.

Situația dinainte de 1989

Sistemul de învățământ era centrat în jurul Facultăților de Instalații şi în mai mică măsură Electrotehnică. Se conturau două centre, unul la Bucureşti şi celălalt la Cluj-Napoca, prin meritul profesorilor Cornel Bianchi şi Florin Pop. Accesul la informație era extrem de limitat iar schimbul de documentație era limitat la mediile universitare.

Producția de aparate de iluminat de tip profesional (interior sau exterior) era limitată la un furnizor: Elba. Productia de lămpi cu incandescență era realizată la Târgovişte iar cea de lămpi cu descărcări şi balasturi magnetice la Electrofar- Bucureşti.

Proiectarea sistemelor de iluminat era realizată manual. În cazul iluminatului interior cu ajutorul metodei coeficienților de utilizare (prin intermediul unor tabele puse la dispoziție de producător) prin care se estima nivelul mediu de iluminare într-o încăpere. În cazul iluminatului exterior se utilizau curbele de egală iluminare orizontală de la furnizor.

Într- o carte de specialitate dinainte de 1989 existau 16 tipuri de aparate de iluminat interior şi 2 de exterior, ceea ce a condus la denumiri generice întâlnite şi acum în proiecte: FIA, FIRA etc.

Perioada 1990-2006

Sistemul de învățământ s-a caracterizat printr-o deschidere tot mai mare către restul Europei. Numeroase cadre didactice au beneficiat de burse de studiu şi doctorat în Uniunea Europeană, iar după primele proiecte europene Phare destinate exclusiv cadrelor didactice au urmat si cele destinate studentilor, Erasmus, apoi cele de cercetare din cadrul Save. În cadrul schimburilor de profesori şi studenți, trebuie remarcata Helsinki University of Technology, prin dr. Liisa Halonen şi University of Liverpool, prin prof.dr.ing David Carter De remarcat programul Tempus-Phare condus de prof. Ramon San Martin - Universitat Politecnica de Catalunya, prin care s-a înființat la Universitatea Tehnică din Cluj-Napoca Centrul de Ingineria Iluminatului condus de dr. Florin Pop. Acest Centru a fost realizat prin colaborare cu profesorii Ramon San Martin, Liisa Halonen si Luciano Di Fraia (ca externi) si Electrica, Energobit si UBB - Computer Science Department ca interni. În ceea ce priveşte Centrul de Ingineria Iluminatului trebuie subliniată susținerea de care s-a bucurat de la început din partea CIE prin prof.dr. Janos Schanda şi prof. Wout van Bommel.

În 2003 s-a semnat un memorandum între Light & Architectural Environment Laboratory, Kyung Hee University şi Centrul de Ingineria Iluminatului, Universitatea Tehnică din Cluj-Napoca, coordonatori prof. Jeong Tai KIM şi prof. Florin POP.

Trebuie evidențiată şi prima colaborarea public-privată între Facultatea de Instalații din Bucureşti şi Philips România, concretizată prin înființarea CASI Centrul de Aplicații în Sisteme de Iluminat în 1997.

Au demarat programele de cercetare europene din care se evidențiază cele de la Universitatea Tehnică din Cluj-Napoca. Primul contract, coordonat de dr. Marc Fontoynont, a demarat în 1994 şi a constat în studierea materialelor de vitrare, apoi în 1999 a urmat NAS-EnerBuild RTD, coordonat de University College Dublin. La ora actuală este în desfăşurare programul EnERliN, de promovare a soluțiilor de iluminat eficiente în domeniul rezidențial, program coordonat de prof. Georges ZISSIS, Universite Paul Sabatier – Toulouse.

De remarcat cursul postuniversitar de la UTC Bucureşti, condus de prof.dr.ing. Cornel Bianchi, care formează specialişti în domeniul iluminatului din rândul inginerilor şi arhitecţilor.

Începând cu 2005 se realizează certificarea specialiştilor din iluminat prin intermediul unui CAPI (Certificat de Atestare Profesională în Iluminat) acordat de CNRI printr-un nou comitet tehnic condus de dr.ing. Mihai Husch.

Producţia de aparate de iluminat de tip profesional (interior sau exterior) a continuat la Elba şi a constat în diversificarea şi extinderea gamei, precum şi reconfigurarea poziţiei pe piaţă şi a reţelei de distribuţie. Odată cu pregătirea licitaţiei de concesionare a iluminatului public din Bucureşti s-au infiinţat şi s-au consolidat firme mixte pentru producţia de aparate de iluminat exterior: Energobit-Schreder, Luxten şi Philips-Elba (ordine strict alfabetică). În domeniul iluminatului interior au apărut mai multe companii care produc sau asamblează aparate; Almalux, Klausen etc. De notat inaugurarea în 2006 a unei fabrici a concernului Zumtobel Lighting la Curtici.

În ceea ce priveşte piaţa lămpilor, aceasta a început să se adapteze încetul cu încetul la modelul european, prin poziţia dominantă a celor două firme lider: Philips şi Osram şi în mai mică măsură Sylvania şi GE. Firmele româneşti de profil au făcut faţă cu greu acestei concurenţe şi şi-au redus an după an cota de piaţă. În ceea ce priveşte lămpile fluoresente compacte, sunt pe piaţă diverse produse de provenienţă asiatica având o calitate inegală.

Proiectarea sistemelor de iluminat a început să se facă progresiv cu ajutorul programelor de calcul. Dacă la începutul anilor 90 fiecare universitate şi producător aveau propriul program de calcul şi aici s-a resimţit procesul de concentrare după anul 2000 prin utilizarea pe scară largă a programelor Dialux şi Relux. Avantajul acestor programe rezidă în fiabilitate, posibilitatea unor geometrii deosebite, preluarea şi exportarea unor desene în AutoCAD şi de comparare a produse diferite de la producători diferiţi. Nu în ultimul rând avantajul este faptul că aceste programe sunt gratuite şi pot fi descărcate de pe Internet.

2007

Momentul aderării la UE poate fi considerat ca un moment de cotitură: cu un sector al construcţiilor cu o creştere anuală de peste 15% şi cu adoptarea în regim rapid a diverse norme europene, proiectanţii de sisteme de iluminat sun supuşi unor presiuni puternice. Pe de o parte au intrat în vigoare norme noi SR- EN 12464, norme noi de mediu, pe de altă parte au apărut firme de consultanţă străine în iluminat care au avantajul unor lucrări de anvergură în portofoliu iar pe de altă parte toţi marii producători mondiali de echipamente sunt prezenţi în România.

Care sunt aşteptările actuale ale proiectantilor din partea furnizorilor?

- documentatie
- programe de calcul si baze de date
- biblioteci cu aparte sub forma 2D sau 3D
- standarde si normative
- suport tehnic in evaluarea solutiilor
- mostre de echipamente
- bugetarea lucrarilor

Un aspect extrem de important îl reprezintă specificarea aparatelor de iluminat în proiect, aspect care va fi trecut în vedere în ceea ce urmează.

SPECIFICAREA APARATELOR DE ILUMINAT

Introducere

Acum doi ani am fost solicitat să fac măsurări ale nivelului de iluminare. Investitorul străin a cerut prin tema de proiectare un nivel de iluminare mediu de 200 lx şi dorea o verificare. Rezultatele măsurărilor au arătat un nivel mediu de 96 lx, care conducea la un nivel de iluminare menţinut de 76 lx. Cum numărul de aparate de iluminat din proiect a fost respectat, se putea concluziona că avem de face cu o greşeală de proiectare. După studierea proiectului s-a constatat că s-au efectuat calcule bazate pe un aparat de iluminat 2x58 W/840 cu reflector industrial de la un fabricant de referinţă, dar s-a specificat aparat de iluminat 2x58 W, fără menţionarea caracteristicilor sau a tipului de lampă. Antreprenorul a achiziţionat aparate de iluminat 2/58 W pentru birouri, cu montaj aparent, cu grătar şi lampa 58 W/54. după înlocuirea aparatelor şi a lămpilor cu cele avute în vedere de poiectant s-a obţinut un nivel de iluminare mediu de 245 lx.

Din acest incident, rezultă importanţa specificaţiei tipului de aparate de iluminat, pentru a se evita confuziile şi situaţiile conflictuale de pe şantier. În lipsa unor specificaţii clare, antreprenorul va alege cel mai ieftin aparat de iluminat cu caracteristici cât mai apropiate de cel specificat. Până în

1990, în condițiile unui singur furnizor de aparate de iluminat se menționa în proiecte denumirea comercială a produsului. În condițiile economiei de piață şi în cazul proiectelor bugetare este exclusă menționarea denumirii comerciale. În aceste condiții se pune problema specificării tipului aparatului de iluminat intr-un mod cât mai neutru (în anumite cazuri se menționeaza producătorul, codul, dar trebuie menționat "sau similar"). Fac excepție investițiile private în care beneficiarul a ales unul sau mai mulți producători, specificați prin tema de proiectare.

Procesul de proiectare
Pentru echipamentele de instalații este o practică comună să se înlocuiască produsele specificate în faza de procurare cu unele similare, de obicei mai ieftine. În cazul multor echipamente de instalații este uşor să se facă comparații între produsele specificate şi cele similare pentru a stabilii dacă au performanțe asemănătoare.

În cazul iluminatului, sunt mai mulți factori care trebuie luati în considerare, de la performanța energetica şi distributia fluxului luminos trecand prin protecția contra electrocutarii, întreținere şi culminând cu estetica produsului. Acceptarea alternativelor este o procedură complexă şi alegerea unei alternative nepotrivite poate avea consecințe serioase în ceea ce priveşte sistemul de iluminat (de la nivelul de iluminare până la încadrarea în arhitectura clădirii).

Proiectanții sistemelor de iluminat care nu dau specificații suficient de precise şi clare se expun unor pocese cu beneficiarii sau neplății serviciilor de proiectare, în cazul în care sistemul de iluminat nu corespunde cu cerințele menționate în tema de proiectare. Din păcate, nu este prea clar cum trebuie să arate aceste proceduri de specificare şi de multe ori proiectanții sunt presați de alți participanți la proiect să ia decizii care au la bază alte criterii decât cele tehnice.

În discuțiile dintre proiectanți se simte frustrarea lor, când după ce au lucrat vreme de luni la un proiect, studiind cataloage, discutând cu clienții, stabilind soluții de comun acord cu arhitecții asupra celor mai potrivite aparate de iluminat din spațiile cheie, vine un antreprenor care face presiuni pentru acceptarea unor alternative ieftine. Pe de altă parte, această specificare nu trebuie sa limiteze posibilitățile fabricanților sau antreprenorilor de a negocia şi a obține un proiect, dar este sarcina proiectantului de a asigura cea mai bună opțiune pentru client. De aceea proiectantul trebuie consultat pentru orice alternativă sau modificare a proiectului, pentru a avea un aviz tehnic asupra soluției.

Procesul de achiziție
În faza de achiziție a aparatelor de iluminat pentru un proiect, antreprenorul caută soluții similare cu cele propuse de proiectant dar la costuri mai mici sau se încearcă schimbarea soluției prin alegerea unor aparate ieftine (de obiciei aparate modulare înglobate 600x600 cu 4x18W). Aceste soluții alternative pot aduce economii substanțiale care sunt întotdeauna mai ales în avantajul antreprenorului şi câteodată sunt propuse ca avantaje financiare pentru clienți. Exista şi alte motive pentru care se oferă soluții alternative, care nu sunt neaparat mai ieftine: timp de livrare, scoaterea din fabricație a unui produs, scadența plății etc. Acestea sunt situații anormale, deoarece nu se pot întâmpla într-un proiect bine gestionat.

Nu trebuie înțeles de aici că orice soluție alternativă este automat inferioară celor specificate. Există situații când antreprenorul alege o soluție mai scumpa deoarece reduce manopera şi timpul de execuție (de obicei aparatele de iluminat sunt printre ultimele echipamente montate şi suferă din cauza întârzierilor la celelalte capitole). Pentru anumite aparate de iluminat uzuale există produse similare de la zeci de producători şi diferența ține de calitate, uşurința de montaj etc. În aceste situații, antreprenorul vine cu un produs alternativ cu performanțe şi aparență asemănătoare şi nici proiectantul şi nici beneficiarul nu au obiecții. Un bun antreprenor cunoaşte mult mai bine piața aparatelor de iluminat decât un proiectant, în special pe partea financiară şi există un interval de 6-12 luni între momentul selectării unui produs şi cel al punerii în operă.

Problema responsabilității
Este un subiect delicat până unde merge responsabilitatea proiectantului sistemului de iluminat: în multe situații reale, în care proiectantul a furnizat un sistem care respectă normele în domeniu şi cerințele beneficiarului, rareori este contactat de beneficiar sau antreprenor pentru a îşi da avizul asupra alegerii furnizorului şi a soluțiilor alternative. Pe de alta parte, atunci când apar modificări ale planurilor de arhitectură sau neînțelegeri referitoare la soluția propusă, proiectantul este solicitat urgent pe şantier. Chiar dacă nu este consultat în anumite faze ale derulării lucrării, dacă la sfârşit beneficiarul nu este mulțumit de parametrii cantitativi sau calitativi ai instalației se va încerca trecerea vinei exclusiv pe umerii proiectantului. Implicarea proiectantului în alegerea unei soluții alternative implică alocarea de timp (cuantificabil financiar – de ex. urmărire de şantier) cu asumarea unor riscuri legale (acționarea în justitie în cazul nerespectării contractului).

Un alt subiect delicat rezidă în faptul că în procesul de alegere al aparatelor sunt implicaţi beneficiarul, arhitectul, designerul de interior şi proiectantul de instalaţii electrice. Dacă toate aceste părţi nu sunt consultate în acceptarea unor soluţii alternative există riscul ca proiectantul să ajungă într-o poziţie delicată în final.

În sine, procesul de specificare al unui aparat de iluminat este delicat, deoarece implică atât performanţe tehnice cât şi criterii estetice. Deoarece aparatul de iluminat este în sine un obiect vizibil, cu implicaţii majore asupra esteticii interioare, alegerea designului unui aparat de iluminat şi apoi specificare lui este un proces lung. De obicei, beneficiarul şi arhitectul solicită sa vadă un aparat de iluminat pe viu înainte de luarea unei decizii (proces îndelungat, cu multe reveniri şi schimbări). O specificaţie bazată doar pe caracteristici tehnice nu dă nici un fel de clarificări legate de estetica aparatului de iluminat.

Alegerea aparatelor de iluminat reprezintă o responsabilitate care trebuie înţeleasă ca atare de către proiectant şi trebuie cuprinsă în contractul de proiectare sau în urmărirea de şantier. În cazul în care nu se doreşte o asemenea obligaţie datorită volumului mare de timp pe care îl presupune, proiectantul işi ia responsabilitatea doar pentru performanţele tehnice, ceea ce nu este aşa de simplu precum pare. Dacă antreprenorul alege un aparat de iluminat alternativ, cineva trebuie să facă verificări dacă este conform cu standardele specificate, respectiv rezultatele calculelor sunt identice şi furnizează acelaşi nivel de iluminare pe suprafaţa de lucru ca şi aparatul de iluminat specificat. În aceste sens este ideal ca aceasta comparaţie să se facă cu un program independent ca şi DiaLux sau Relux, care utilizează baza de date de la producători şi nu cu programele de calcul furnizate de fiecare producător în parte. În general proiectanţii sistemului de iluminat nu sunt plătiti pentru aceste verificări iar în cazul în care antreprenorul se implică, aceasta inseamna re-proiectare, ceea ce este problematic în cazul în care ceva nu merge bine.

În mod ideal, proiectantul sistemului de iluminat va fi în poziţia de a realiza o evaluare completa a oricărei alternative propuse şi va fi plătit pentru munca suplimentară depusă. În acest caz, sunt anumite criterii care trebuie aplicate atunci când se realizează o astfel de evaluare:

- Taxe profesionale – proiectanţii vor face o astfel de evaluare a alternativelor propuse doar atunci când ele au fost specificate în contractul iniţial sau au primit indemnizaţii alternative. Dacă nu se fac astfel de aranjamente proiectanul nu va dori sau nu se poate pronunţa asupra oricăror alternative înaintate. Dacă proiectantul este însărcinat de antreprenor/producător să execute o astfel de evaluare, trebuie făcută o separare profesională clară între originalul proiectat şi evaluarea alternativă printr-o abordare neutră şi obiectivă.
- Echivalenţa fotometrică – proiectantul poate cere caracteristici fotometrice complete pentru toate aparatele de iluminat oferite alternativ, inclusiv curbe polare sau echivalente. Evaluarea trebuie să utilizeze aceeaşi parametri ca şi calculele originale pentru a fi siguri că aparatul de iluminat alternativ îndeplineşte sau depăşeşte parametrii ceruţi.
- Consumul energetic al instalaţiei de iluminat – se face comparaţia consumului de energie între aparatul de iluminat specificat şi alternativa propusă.
- Constructie şi robusteţe – confirmarea calităţii, durabilităţii şi robusteţii egale poate necesita mostre atât din produsul specificat cât şi cele similare. Aceasta nu înseamnă ca aparate de iluminat mai puţin robuste nu pot fi acceptate de către beneficiar, dar cel puţin trebuie avute în vedere în evaluare.
- Accept estetic – aparatele de iluminat alternative trebuie luate în considerare atât individual cât şi în relaţie cu alte aparate de iluminat din proiect pentru a asigura acceptanţa estetică. Această procedură trebuie să includă şi o evaluare a aparatelor în funcţiune (aprinse) şi va fi realizată împreună cu arhitecţi, designeri, client şi alte părţi interesate. În cazul iluminatului exterior, evaluarea se va face şi în funcţie de sistemul de fixare şi suporturi.
- Echivalenţa electrică – în proiectele cu caracteristici speciale pentru aparate, alternativele propuse vor fi evaluate pe baza aceloraşi criterii. Compatibilitatea componentelor şi sistemelor va fi verificată pentru a asigura siguranţa şi pentru a menţine performanţele proiectului original (ex. efectul schimbării balastului asupra duratei de viaţă). Factorul de putere, caracteristicile dielectrice, interferente cu frecvenţele radio, tensiuni de vârf şi conductele din interiorul aparatului trebuie evaluate împreună cu multe alte caracteristici electrice.
- Echivalenţa altor proprietăţi tehnice- aparatele de iluminat propuse trebuie să aiba ataşată fişa tehnică şi specificaţii tehnice care să ateste compatibilitatea cu standardele româneşti şi cu cele europene. Atunci când performanţele aparatului de iluminat propus diferă de cele ale aparatului specificat trebuie argumentată soluţia alternativă.
- Intreţinere – în evaluare trebuie avute în vedere usurinţa şi simplitatea întreţinerii; factorul de mentenanţă trebuie să fie identic sau mai mare decât cel specificat de proiectant.

- Beneficii – indiferent că beneficiile sunt financiare, usurința de instalare sau economia de timp, acestea trebuie clar menționate în propunerea de schimbare a aparatelor de iluminat specificate.

Protejarea intereselor
Conceptul de “identic sau similar” este utilizat de mai mulți ani în Europa şi va fi probabil folosit şi în anii urmatori. De aceea este important ca proiectanții sistemelor de iluminat să-şi protejeze nu doar propriile interese, ci şi pe ale clienților. Procesul descris anterior dă un cadru clar pentru o evaluare structurată care să rezolve toate problemele şi care să fie usor de înțeles pentru toți membrii echipei de proiectare.

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ILUMINATUL URBAN ÎN ROMÂNIA – PROBLEME ACTUALE

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REZUMAT

Lucrarea prezintă câteva aspecte ale mediului luminos urban din România, care, printr-o tratare necorespunzătoare în concepție sau menținere, pot conduce atât la degradarea vizuală a ambientului, cât şi la accidente.

Mediul luminos urban de seară şi / sau noapte este definit prin componentele sale cantitative şi calitative, care, printr-o judicioasă alegere şi coordonare logică, pe baza cercetărilor şi experienței naționale şi internaționale, reflectate in recomandările şi normele Comisiei Internaționale de Iluminat (CIE) şi a celor europene, în special din deceniul al X-lea al secolului 20, pot conduce la o soluție corectă a sistemelor de iluminat electric.

Acest iluminat poate crea o altă imagine, care poate fi uneori mult mai bună, mai bună, similară, mai slabă sau mult mai slabă decât cea realizată de iluminatul natural.

Prin posibilitățile pe care le oferă iluminatul electric, se pot obține efecte deosebite datorită faptului că, spre deosebire de iluminatul natural, creat de natură, cel electric este creat de experiența tehnicii umane, din considerente logice, artistice / estetice şi funcționale. În funcție de pregătirea echipei de concepție în acest domeniu, soluția aleasă poate conduce la realizări deosebite inițiale, dar care necesită operații periodice de menținere şi de acordare (sincronizare) cu vegetația abundentă în special pentru căile de circulație auto din România.

1 CONEXIUNEA DINTRE ILUMINATUL CĂILOR DE CIRCULAȚIE DIN ROMÂNIA ŞI VEGETAȚIA ADIACENTĂ, ASPECT DETERMINANT ÎN REALIZAREA CANTITATIVĂ ŞI CALITATIVĂ A UNUI MEDIU LUMINOS CORESPUNZĂTOR

Dacă în domeniul profesioniştilor din Uniunea Europeană acest aspect este luat întotdeauna în considerare în concepția, realizarea şi MENȚINEREA / ÎNTREȚINEREA sistemelor de iluminat destinate acestor căi frecvent întâlnite în multe zone urbane, la noi este total neglijat / uitat în marea majoritate a cazurilor, ceea ce conduce la:

- CANTITATIV – micşorarea nivelului de luminanță în zonele ecranate de până la 10 ori față de valoarea calculată şi uneori chiar mai mult;
- CALITATIV – scăderea excesivă şi inadmisibilă a nivelului de uniformitate L_{min} / L_m până la 0,1 şi chiar mai puțin.

Trebuie menționat că majoritatea celor care concep sistemele de iluminat stradal, fie „uită" de vegetație, fie nu țin seama de aceasta, pentru că în majoritatea planurilor studiate şi tratate ea nu este figurată.

Această situație este inadmisibilă pentru România, actuală componentă a Uniunii Europene şi ea trebuie remediată de urgență.

Pe de altă parte, un proiect corect trebuie să indice detaliat atât montarea corectă a aparatelor de iluminat, cât şi modul în care trebuie să se realizeze permanent menținerea şi întreținerea vegetației aferente, care trebuie semnalată şi contorizată permanent între concepție, realizare (instalare) şi menținere permanentă bivalentă: structură sistem şi adaptare vegetație (v. Figura 1).

Soluția ideală de menținere / întreținere este ca aceeaşi firmă să realizeze ambele operații 3.1 şi 3.2, în aşa fel încât să fie sub acelaşi control. În cazul separării 3.1 de 3.2 apar şi au apărut acuze reciproce, iar rezultatul final la ora actuală tinde către zero.

Se impune o implementare de legislație urgentă în scopul obținerii unui iluminat corect, pentru a se evita, aşa cum se întâmplă în majoritatea cazurilor azi la noi, scăderea parametrilor până la de 10 ori, din cauza ecranării frecvente, aproape totale, a aparatelor de iluminat pe zonele cu vegetație abundentă necorelată în proiectul inițial în majoritatea cazurilor.

Pentru ca sistemele de iluminat destinate căilor de circulație auto cu zone laterale (de trotuare) pe care sunt plantați arbori cu coronament dezvoltat să fie corespunzătoare ca valoare a luminanței medii şi ca uniformitate, este necesară corelarea înălțimii de montare a aparatelor de iluminat cu dimensiunile coronamentului copacilor aşa cum indică publicațiile internaționale.

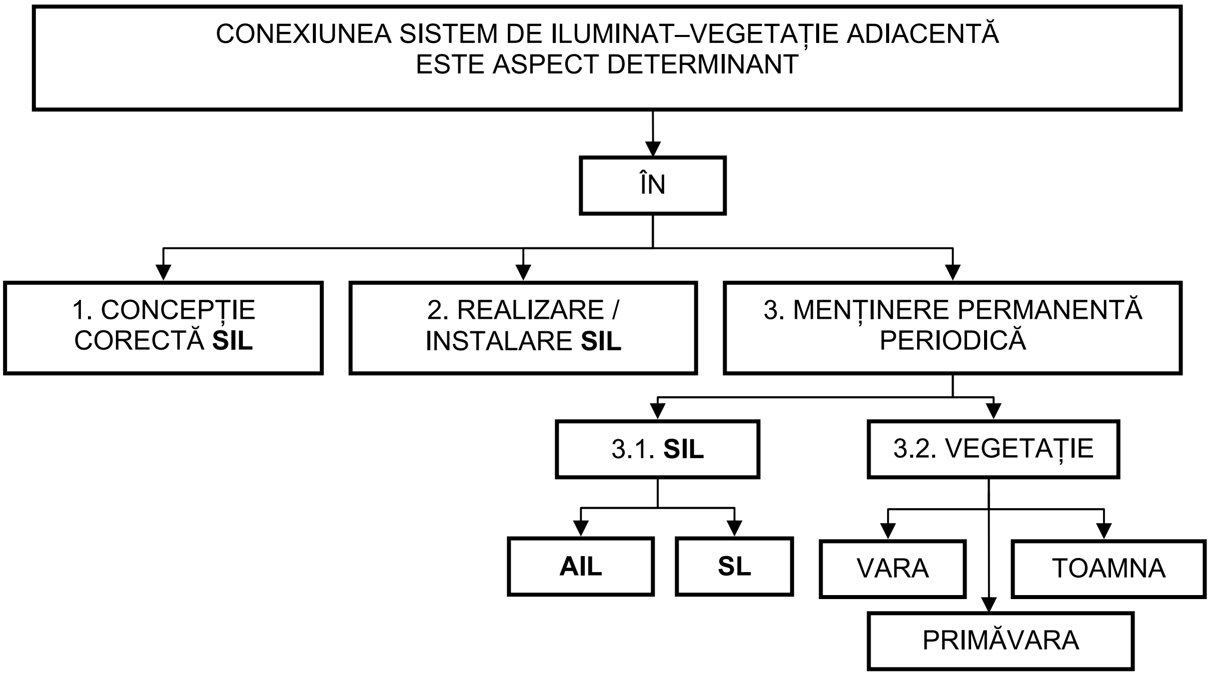

Figura 1 Structura schematică a conexiunii SIL-vegetație: SIL-sistem de iluminat; AIL-aparat de iluminat; SL-sursă de lumină

O altă greşeală care s-a făcut uneori la noi este montarea de aparate de iluminat pe străzi înguste cu două căi şi cu vegetație redusă sau deloc, la înălțimi foarte mari (10-15 m) , ceea ce face ca sistemul să fie neeficient economic sau să nu respecte nivelurile actuale ale standardelor româneşti, preluate după cele ale CIE / EU.

Pentru căile de circulație cu bandă (verde) centrală fără arbori, este recomandată soluția sistemului central (axial) dublu orientat, ca în Figura 2, care, din păcate, pe străzile din Bucureşti şi nu numai practic nu este aplicată. Soluția este ideală atât din punct de vedere funcțional, cât şi din cel al evitării ecranării de către vegetație.

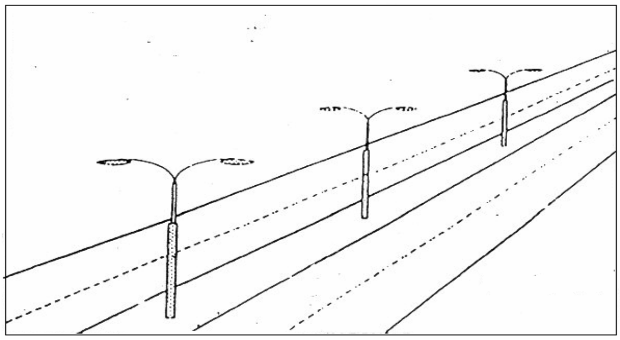

Figura 2 Sistem de iluminat central dublu orientat

Şi în această situație, dacă nu sunt iluminate separat şi independent trotuarele, este necesară corelarea geometrică între amplasarea aparatelor de iluminat si coronamentul arborilor.

2 POLUAREA LUMINOASĂ ÎN MEDIUL URBAN

Poluarea luminoasă în mediul urban a fost subiectul tratat în ultimii 10 ani de către CNRI şi Catedra de Luminotehnică a UTCB, iar prin soluțiile sugerate prin învățământul postuniversitar, prin legislația de asociație şi cea oficială şi, nu în ultimul rând, prin necesitatea membrilor asociați şi membrilor CNRI, s-au realizat progrese remarcabile, azi rămânând numai cazuri izolate de concepție incorectă, majoritatea poluării fiind determinată de sistemul „necontrolat“ al reclamelor.

Reamintim că poluarea în mediul urban este determinată de cele două aspecte calitative, determinante fiind fie luminanţele ridicate, diferenţe mari / foarte mari de luminanţe, fie culoarea aparentă necorespunzătoare sau amestecul de culori.

2.1 Poluarea luminoasă funcţie de luminanţă

Poluarea luminoasă poate fi produsă de luminanţe ridicate sau de diferenţe de luminanţe mari şi foarte mari, aspecte ce acţionează negativ asupra organului vizual uman, provocând, în funcţie de valori, orbire fiziologică sau psihologică, care scad, în funcţie de valori de la puţin la mult, foarte mult, capacitatea vizuală a observatorului la volan sau nu, putând provoca accidente, în plus faţă de dezagrementul vizual.

Distribuţiile de luminanţe cu contraste mari şi lipsa ecranelor protectoare sunt azi soluţii curente în reclamele imense iluminate sau în montaje particulare apărute în arii vizibile şi zone curente de crculaţie. Singura metodă de eliminare este legislaţia şi organele locale care să fie instruite pentru aplicarea lor.

În general, aparatele de iluminat greşit directionate sau de calitate scăzută practic nu se mai înregistrează azi decât în zone marginale-periferice, de calitate scăzută a unor oraşe şi în zona rurală cu circulaţie redusă. Ele trebuie de asemenea eliminate prin competenţa şi perseverenţa organelor locale, care trebuie să se preocupe permanent şi eficient şi de al doilea aspect determinant al culorii aparente urbane (v. 2.2).

Un alt aspect negativ, care apare azi în unele oraşe, în structura iluminatului căilor de circulaţie pietonale paralele, dar nemascate vizual faţă de căile de circulaţie auto, sunt poluările produse de luminanţa aparatelor de iluminat din această zonă pentru conducătorii la volan.

Astfel, atunci când a fost conceput sistemul de iluminat pietonal nu s-a ţinut seama că acesta este total vizibil fiind tangenţial celui auto. Uitând / neglijând acest aspect s-au montat aparate de iluminat total / parţial neprotejate vizual (tip felinar) la înălţimi sub 3 m, ca şi când zona respectivă ar fi într-un parc exclusiv al pietonilor.

2.2 Poluarea luminoasă prin culoare aparentă

În deceniile al VI-lea, al VII-lea şi parţial al VII-lea, existau numai sursele cu descărcări în vapori de mercur la înaltă şi joasă presiune, astfel încât, pentru iluminatul destinat circulaţiei şi cel urban, singura soluţie economică din punct de vedere energetic era utilizarea acestora, cu menţiunea combinării cu vechea sursă existentă (descărcări în vapori de sodiu la joasă presiune), cu emisia exclusivă pe 589 nm, de o eficacitate luminoasă maximă, dar cu o redare nulă a culorilor.

Apariţia lămpii cu descărcări în vapori de sodiu la înaltă presiune, la sfârşitul deceniului al VII-lea, dezvoltată şi implementată începând din deceniul al VIII-lea al secolului 20, a făcut ca întreaga structură a iluminatului urban să se schimbe datorită calităţilor deosebite ale acestei surse.

Se remarcă eficacitatea luminoasă dublă faţă de lămpile clasice cu vapori de mercur la înaltă presiune, cu 60÷80% mai mare decât cele moderne (cu adaosuri de ioduri metalice), cu 70÷100% faţă de lămpile fluorescente.

Durata de funcţionare depăşeşte cu mult celelalte surse, ajungând chiar la de trei ori, în condiţii de exploatare favorabile, iar la ultima generaţie cu două tuburi de descărcare tinzând către dublarea duratei. Cel mai important aspect, din punctul de vedere al conexiunii „Lumină-Vedere“, este culoarea luminii emise şi a structurii spectrale în comparaţie cu sensibilitatea ochiului uman (Figura 3.a). În Figura 3.b este dată structura emisiei şi desenată curba înfăşurătoare (C.Î.) care este similară cu curba vizibilităţii relative fotopice, având aproape acelaşi maxim.

Speculaţiile făcute fie din necunoaştere, fie din rea-credinţă pentru promovarea altor surse, cu referire la cealaltă curbă scotopică, sunt total necorespunzătoare pentru că valoarea de referinţă a acestei curbe este 0,035 cd/m^2, iar la cea fotopică de L_f=3,5 cd/m^2 care este mult mai apropiată de valorile standard M_1=2 cd/m^2 şi M_5=0,5 cd/m^2 faţă de cea scotopică.

Nici una din celelalte surse, cum ar fi sursa cu mercur la înaltă presiune cu balon fluorescent sau cea cu adaosuri de halogenuri metalice, nu prezintă o structură similară, fiind total diferite de CVR!

Iată deci că lampa cu vapori de sodiu la înaltă presiune îmbină în mod fericit caracteristicile vederii umane cu cele ale sursei emiţătoare, ale cărei aspecte pozitive deosebite au fost relevate înainte.

Studiile întreprinse de către Catedra de Luminotehnică şi Instalaţii Electrice din cadrul UTCB - Facultatea de Instalaţii şi de către CNRI au continuat cercetările recente realizate pe plan mondial în această privinţă. Astfel, testele „in situ“ realizate în Bucureşti [8] şi în Timişoara [9], au demonstrat că cea mai plăcută este culoarea alb-auriu (alb-galben) (70%-90% din subiecţi).

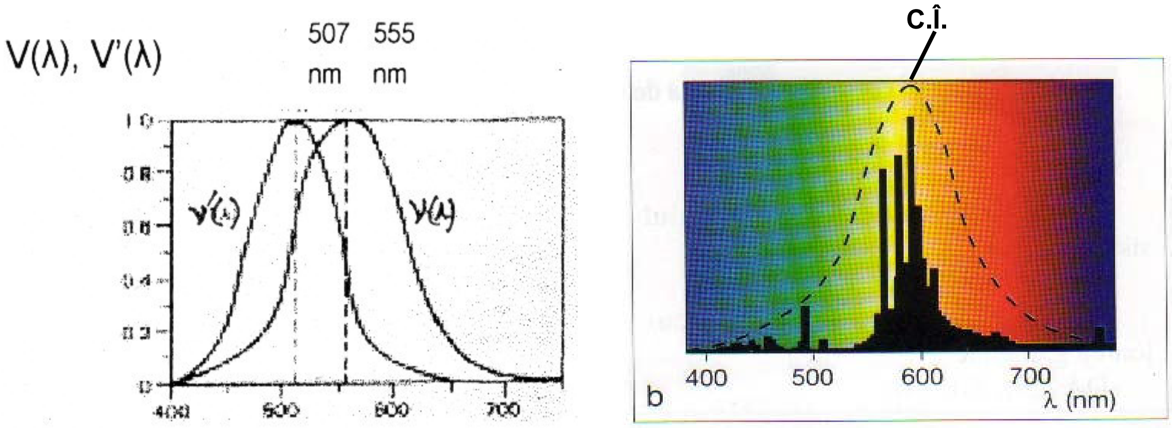

Figura 3 Comparaţie între curbele caracteristice ale vederii umane şi curba înfăşurătoare a lămpii SON standard:
a. Curba vizibilităţii relative a ochiului uman pentru vederea de zi (CVR) (fotopică) V(λ) pentru $L \approx 3{,}5 cd/m^2$ şi curba vizibilităţii relative V'(λ) pentru vederea de noapte (scotopică) pentru $L \approx 0{,}035\ cd/m^2$;
b. Structura emisiei spectrale a lămpii SON standard şi curba înfăşurătoare a emisiei spectrale (C.Î.-cu linie întreruptă)

Trebuie menţionat faptul că subiecţii interogaţi au fost atât oameni obişnuiţi abordaţi la întâmplare, cât şi dintre cei cu o pregătire generală superioară.

În general, redarea modestă a lămpii standard nu deranjează în ansamblul global urban, iar pentru anumite obiecte, zone, care cer o redare acceptabilă - bună - foarte bună, aceasta poate fi realizată prin lămpile de calitate superioară SON Confort (R_a = 60), SON White (R_a = 85), la care, evident, prin adaosurile introduse, scade eficacitatea luminoasă sau, în situaţii speciale, cu alte surse cu $R_a > 80$ dar în limita unei diferenţe de T_c de max.30% (ex.: LIH*[*] sau CDM**[†]).

Concluzionând, pentru aspectele relevate, lampa cu vapori de sodiu la înaltă presiune îndeplineşte condiţiile cantitative şi calitative care o fac să fie o opţiune optimă pentru zonele climatice temperate sau reci.

Din punctul de vedere al efectului psihologic al culorii, trebuie reamintit că preferinţa observatorilor din zonele calde geografice (tropicale şi ecuatoriale) este cea a culorilor moderate către reci, deci total diferite de zonele europene similare, ceea ce schimbă total condiţiile de abordare a soluţiei din punctul de vedere al culorii aferente.

2.3 Poluarea prin „amestecul" de culori

Schimbarea / amestecul culorilor în sistemele de iluminat urban provoacă solicitări vizuale şi estetice deosebite, care pot compromite un sistem corespunzător din punct de vedere cantitativ şi calitativ (al distribuţiei luminanţelor şi direcţionării luminii).

Dacă solicitările vizuale sunt receptate de sistemul vizual, conducând uzual la şocuri mai puternice sau mai reduse în funcţie de contrastul de culoare care determină reducerea capacităţii de sesizare şi control, cele estetice sunt receptate selectiv în funcţie de structura şi de gradul de cultură, de „gusturile" subiecţilor şi de celelalte aspecte privind reacţia diferitelor persoane la diferite amestecuri de culori.

În general, efectele amestecului de culori se reflectă asupra sistemului vizual uman pe două căi:

- adaptarea cromatică la trecerea dintr-o zonă în alta sau de la un obiectiv la altul (efect psihologic + fiziologic), evident cu un grad mai redus decât adaptarea de la luminanţe foarte mari la luminanţe foarte mici;
- şocul estetic produs de schimbarea culorii, care provoacă o senzaţie vizuală neplăcută, ce conduce la o imagine supărătoare, deranjantă.

Experimentele întreprinse de către Catedra de Luminotehnică şi Instalaţii Electrice din cadrul UTCB - Facultatea de Instalaţii şi de către CNRI pe subiecţi au confirmat opţiunea normală: menţinerea aproximativ constantă a temperaturii de culoare (caldă) pentru toate aplicaţiile şi obiectivele din iluminatul urban!

[*] / LIH-lampă incandescentă cu ciclu regenerativ cu halogeni

[**] / CDM-lampă cu descărcări în vapori de mercur la înaltă presiune şi cu adaosuri de halogenuri metalice având $T_c \approx 3000$

Pentru obiective speciale, redarea bună - foarte bună se poate obţine şi cu SON White (SDW). Dacă se consideră însă necesitatea unei redări excelente se poate utiliza LIH (lampa incandescentă cu halogen).

De menţionat că cele din gama MH prezintă o redare foarte apropiată de SDW, iar dacă se alege o astfel de soluţie nu se va depaşi T_c=3000 K pentru alegerea făcută (CDM).

Din păcate lipsa de cunoaştere corectă a faptului că între temperatura de culoare şi redarea culorilor nu există nici o legătură, datorită proprietăţii metamerismului de culoare al vederii umane, conduce la confuzii grave şi la soluţii greşite.

Soluţiile de sisteme de iluminat pentru circulaţia auto, bazate pe teorii depăşite, au creat de asemenea, nu cu mult timp în urmă în România şi nu numai, soluţii necorespunzătoare şi supărătoare pentru mediul urban.

Teoriile elaborate în urmă cu mai mult de 45 de ani, privind schimbarea culorii ca o condiţie de semnalizare, <u>nu</u> au ţinut seama de adaptarea cromatică şi de aspectul amestecului de culori, considerându-le probabil ca neesenţiale pentru mediul luminos urban în raport cu ideea „semnalizării" sau pur şi simplu neglijându-le.

În final, trebuie menţionat că „pas cu pas" pe plan european, iar azi şi în România, sistemele diferenţiate, create iniţial pentru semnalizare, au fost înlocuite mai repede sau mai încet, unele fiind deja eliminate total.

În România, de asemenea, atât datorită promovării profesionalismului de către CNRI şi universităţi având catedre / colective specializate (Universitatea Tehnică de Construcţii Bucureşti, Universitatea Tehnică Cluj-Napoca şi Universitatea Politehnica din Timişoara), cât şi receptării sale de către principalii aplicanţi: ELBA, ELECTRICA, ENERGOBIT, FLASH, LUXTEN, PHILIPS & ELBA STREET LIGHTING, în ultimii ani s-au făcut progrese deosebite în acest domeniu, în Bucureşti şi în toate oraşele ţării.

Mai trebuie menţionat aspectul pe care îl pun în evidenţă studiile realizate de către Catedra de Luminotehnică şi Instalaţii Electrice din cadrul UTCB - Facultatea de Instalaţii [8], la trecerea de la străzile secundare (surse cu mercur la înaltă presiune) la cele principale (surse cu sodiu la înaltă presiune), diferite ca nivel de luminanţă şi culoare, care au arătat prioritar, pe subiecţi necalificaţi, o stare de relaxare pentru mai mult de 50 % din subiecţi.

Acest aspect a fost de asemenea testat de CNRI şi în structurile modernizate, echipate cu surse de sodiu la înaltă presiune, la trecerea de la 0,5 cd/m^2 la 2 cd/m^2, reacţiile unora fiind similare, dar într-un procent mai redus sesizat.

Senzaţia de liniştire / relaxare, aşa cum au aratat şi unele cercetări internaţionale, suprapusă peste o stare de stress a subiectului, verificată şi de principalul autor „in situ", poate conduce, în mod greu de înţeles la prima percepţie, la o verificare vizuală superficială a străzii „liniştitoare", bine iluminate, care poate conduce la accidente.

Pentru a evita aceste aspecte care pot conduce la accidente devine necesară crearea unei zone de tranziţie pentru adaptarea vizuală (v. Paragraful 3).

2.4 Poluarea luminoasă coloristică provocată de reclamele luminoase sau iluminate

Din păcate în ultima perioadă în unele oraşe mari din România şi nu numai, dar în special în capitală, se constată apariţia şi dezvoltarea fără limite a poluării produse de reclamele luminoase şi iluminate de nivel calitativ foarte scăzut care degradează în special imaginea de seară / noapte a zonelor centrale ale Bucureştiului.

Cele mai deranjante sunt panourile „imense" iluminate în culori stridente alb-albastru-verde în totală disonanţă cu ambientul alb-auriu urban şi care atrag atenţia prin proasta imagine şi contrastul de luminanţe care conduce la degradarea mediului luminos urban şi creşterea riscului de accidente.

Chiar dacă şi în alte oraşe europene din zona centrală şi de vest există unele reclame, din păcate pentru noi nicăieri nu apare disonanţa şi diferenţa negativă de calitate aşa cum se manifestă azi în zona centrală a Bucureştiului.

În aceste condiţii numai o legislaţie a organelor centrale şi locale, cu un centru profesional de nivel corespunzător şi permanent, va putea reda o imagine modernă şi de calitate în zonele urbane azi degradate de imaginile luminoase şi iluminate de proastă calitate şi de dimensiuni uneori imense faţă de ambient.

3 ZONA DE TRANZIŢIE – CONDIŢIE VITALĂ ÎN SECURITATEA CIRCULAŢIEI AUTO

Aşa cum s-a precizat şi analizat anterior în iluminatul urban modernizat, la trecerea de la o stradă principală cu nivel maxim de luminanţă de 2 cd/m^2 la una secundară de 0,5 cd/m^2 sau în sens invers, sistemul vizual este solicitat fiziologic, uneori intervenind şi condiţii psihologice personale ale observatorilor de la volan. Astfel devine necesară introducerea, în sistemele de iluminat stradal, a unei zone de adaptare vizuală.

Astfel, cercetările realizate de CNRI şi Catedra de Luminotehnică şi Instalaţii Electrice din cadrul UTCB - Facultatea de Instalaţii, respectiv trecerea de la strada principală, de categorie M_1 (2 cd/m^2, conform normei CIE 115), la una secundară, de categorie M_5 (0,5 cd/m^2) sau M_4 (0,75 cd/m^2) sau în sens invers, de la M_5 / M_4 la M_1, au confirmat şi condus la necesitatea logică de realizare a unei zone de tranziţie de aproximativ 100 m (Figura 4), în care nivelul luminanţei să scadă treptat (de la M_1 la M_5), respectiv să crească treptat (de la M_5 la M_1).

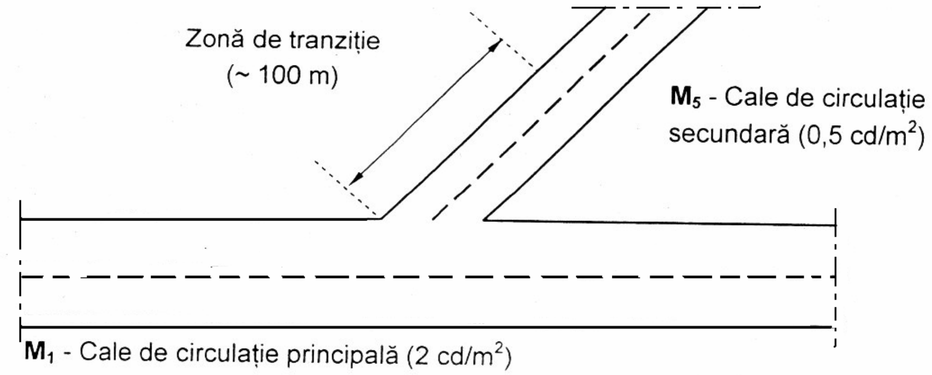

Figura 4 Zona de tranziţie

Trebuie menţionată, de asemenea, prevederea benefică a CIE 115, [1], care trebuie respectată întotdeauna, de realizare a zonei adiacente (surrounding zone), iluminată corespunzător, pentru a evita contrastele de luminanţă mari în câmpul vizual central şi tangenţial periferic, care scad substanţial capacitatea vizuală.

Este determinant ca aparatele de iluminat alese pentru această zonă deschisă (atenţie: nu obturată de vegetaţie abundentă şi joasă !) să fie corespunzătoare ca protecţie vizuală pentru conducătorii auto şi fără emisie laterală disturbantă la înălţime mică de montaj.

O altă problemă actuală, extrem de importantă pentru participanţii la circulaţia auto în zona urbană din România, sunt trecerile de pietoni semaforizate şi, în special, nesemaforizate, în zona de categoria M_1 şi M_2, la care, în peste 90% din situaţii, nivelul de iluminare este necorespunzător, expunând subiecţii la grave accidente. Din păcate nici prevederea elementară veche, majorarea cu 50% a nivelului de iluminare orizontală, nu este şi nu a fost respectată. Trecerile de pietoni fiind zone mare de risc trebuie corelate de urgenţă fie prin niveluri duble de iluminare în plan vertical şi chiar mai mult la cele nesemaforizate (30-50 lx corespunzătoare la M_2-M_1), fie prin contrast negativ (nerecomandate uzual !) în zone de circulaţie auto redusă.

4 CONCLUZII

Sistemele de iluminat urban modern de calitate destinate circulaţiei auto sunt de culoare aparentă corespunzătoare (caldă) atât pentru circulaţia stradală, în diferite zone, cât şi pentru aspectul decorativ / estetic, care creează mediul luminos funcţional, confortabil, estetic, atrăgător, cald, capabil să asigure aceste cerinţe, precum şi senzaţia de securitate.

În prezentarea orală a lucrării figurează câteva exemple de iluminat decorativ / arhitectural de calitate din România, Europa ş.a., coordonat şi armonizat corespunzător cu iluminatul stradal, realizând astfel în ansamblu un mediu urban luminos echilibrat, estetic şi atractiv.

Un alt aspect de bază în calitatea mediului luminos urban de seară şi / sau noapte, este atât menţinerea aceleiaşi armonii coloristice în iluminatul decorativ (clădiri, monumente, statui, biserici / catedrale ş.a.) în limitele menţionate, precum şi minimizarea / eliminarea discrepanţelor vizuale produse de firmele luminoase sau iluminate!

Tratarea superficială şi neprofesionistă poate conduce la alterarea imaginii oraşului pe anumite zone parţial sau total. Suplimentar, ca element „parazitar" / poluant luminos, sunt reclamele luminoase de proastă calitate coloristică, în care densitatea kitsch-urilor este majoritară, diminuând substanţial frumuseţea ambientului urban.

Numai o calificare şi educaţie profesională corespunzătoare, coroborate atât cu exigenţa în concepţia, realizarea şi menţinerea sistemelor de iluminat, precum şi controlul calificat din partea organelor administrative, pot conduce la o imagine optimă a oraşelor seara şi / sau noaptea, demonstrând încă o dată că şi „LUMINA“ aplicată într-un oraş reprezintă viață, securitate, atractivitate şi frumusețe.

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URBAN LIGHTING IN ROMANIA – ACTUAL PROBLEMS

ABSTRACT

The paper presents some aspects of urban lighting environment from Romania that, by an inappropriate approach in designing or maintenance, can lead both to visual degradation of the environment and to accidents.

Evening and / or night urban lighting environment is defined by its quantitative and qualitative components, that, by judicious choice and logical coordination, based on national and international researches and experience, reflected on recommendations and norms of International Commission on Illuminating (CIE) and on European ones, especially in the tenth decade of the twenty century, can lead to a correct solution of the electric lighting systems.

This lighting can create an another image, that can be sometimes much better, better, similar, weaker, much weaker compared to the one realized by natural lighting.

By the possibilities of electric lighting, especial effects can be obtained due to the fact that electric lighting is created by the human technical experience, from logical, artistic / esthetic and functional reasons, compared to the natural lighting. Depending on the education of the designing team in this domain, the chosen solution can lead to especial initial achievements, but which need periodical operations of maintenance and synchronization with the abundant vegetation especially for roads from Romania.

ILUMINATUL INTEGRAT NATURAL-ELECTRIC, CONDIȚIE DETERMINANTĂ ÎN EFICIENȚA SISTEMULUI ENERGETIC CLĂDIRE

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INTRODUCERE

Prezenta lucrare va detalia aspectele sintetizate în prima prezentare a influenței iluminatului în ansamblul energetic al clădirii, tratând atât modul de utilizare şi prelucrare a luminii naturale prin ferestre, cât şi accesul suplimentar realizat la clădirile mari prin structuri spațiale centrale, laterale sau mixte.

De asemenea, în partea a doua vor fi tratate structurile moderne compactizate de transfer al luminii naturale şi anume: tubul de lumină monovalent şi bivalent şi tubul solar (monovalent, bivalent sau trivalent), care permit şi alimentare dublă sincronizată şi integrată (lumină naturală şi electrică), iar la cel solar trivalent şi ventilare naturală controlată.

Utilizarea eficientă a luminii naturale, ca o componentă necesară prin calitățile sale în sistemele de iluminat interior, a devenit azi un aspect deosebit de important în tratarea modernă a concepției sistemelor integrate.

Lumina naturală, extrem de variabilă, prezintă efecte pozitive şi poate conduce la economie de energie (Figura 1), cu condiția unei armonizări cu cea electrică, care trebuie să realizeze permanent compensarea variabilității printr-un sistem integrat dinamic, capabil să asigure mediul luminos interior confortabil, funcțional şi estetic.

Desigur, acest proces se poate realiza printr-o procesare automată şi sincronizare a celor două componente.

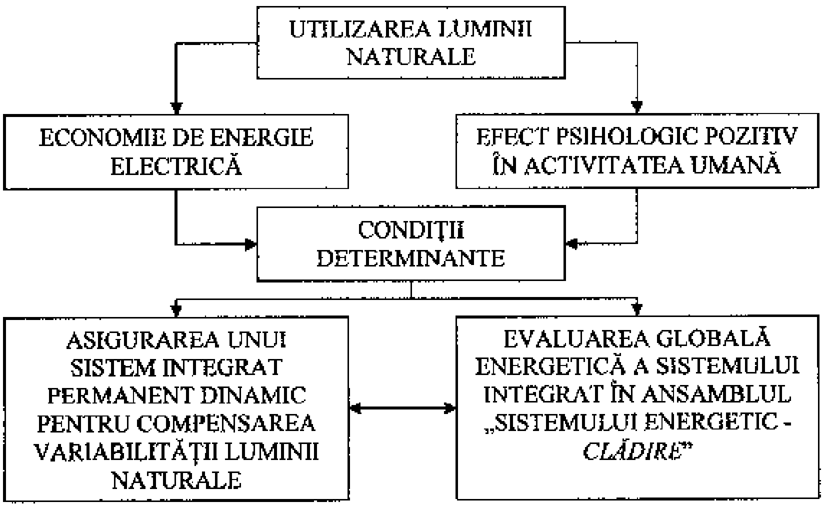

Figura 1 Efectele luminii naturale în iluminatul interior al clădirilor

1 TRANSFERUL LUMINII NATURALE ÎN INTERIORUL CLĂDIRILOR

În general accesul luminii naturale în clădire se poate realiza clasic prin ferestre sau prin structuri interioare, de regulă centrale, atrium-uri, vitrate la partea superioară şi care oferă posibilitatea transferului luminii naturale către zona centrală cât şi către încăperile tangente amplificând şi echilibrând transferul prin ferestrele uzuale. De asemenea sunt practicate şi structuri de transfer al luminii către zonele adiacente prin oglinzi care dirijează şi concentrează „jetul luminos".

Există posibilitatea, deocamdată mai rar aplicată, de utilitare a „tuburilor de lumină" şi a tuburilor solare pentru realizarea transferului luminii, soluție extrem de eficientă şi uşor de aplicat. În Figura 2 sunt schematizate sistemele de acces ale luminii naturale.

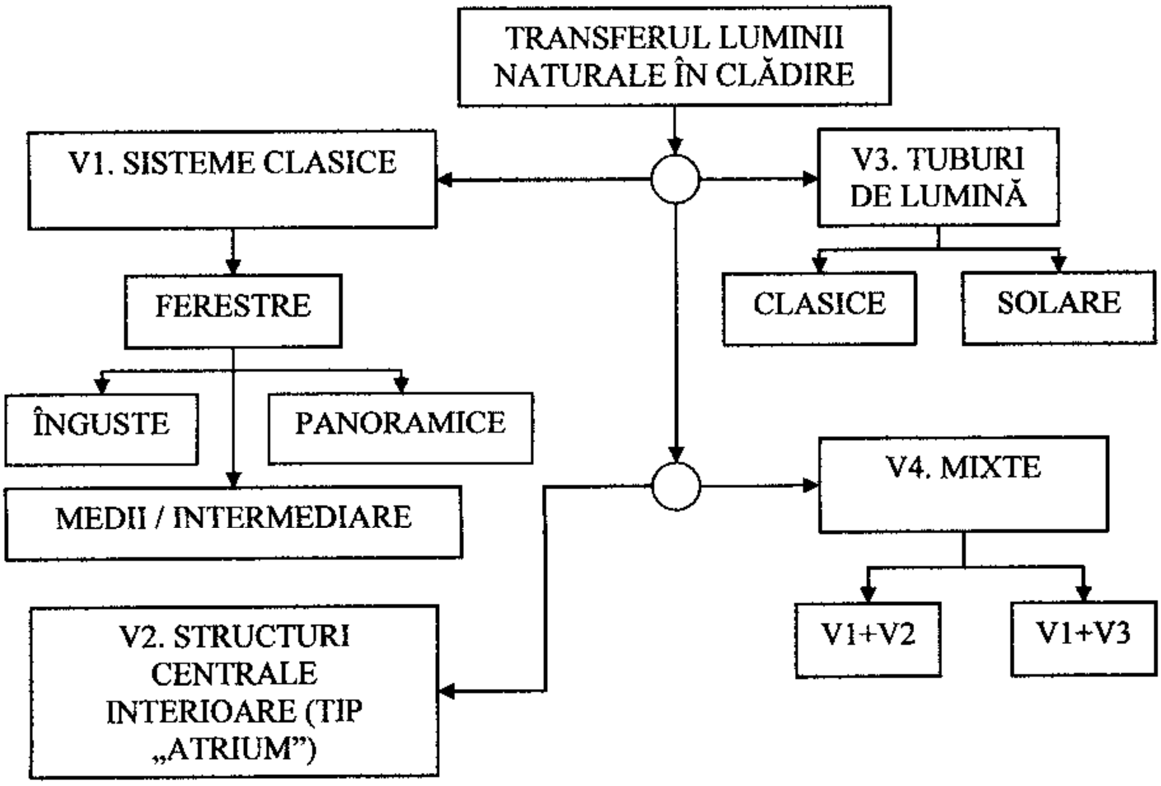

Figura 2 Transferul luminii naturale în clădire

Tendința actuală pentru clădirile destinate activităților umane (muncă intelectuală, fizică sau mixtă), este utilizarea variantei V2, care, pe de altă parte, elimină şi dezavantajul birourilor adânci cu structuri clasice, care necesitau un sistem de iluminat electric interior, suplimentar şi permanent-PSALI (Permanent suplimentary artificial lighting of interior).

Accesul luminii naturale în clădire poate fi realizat atît prin sistemul clasic de ferestre cu lumina prelucrată şi controlată sau/şi prin intermediul structurilor interioare centrale, care oferă posibilitatea transferului luminii naturale prin zonele vitrate laterale către încăperile adiacente. De asemenea, există şi o altă posibilitate, care presupune utilizarea tuburilor de lumină pentru realizarea transferului luminii naturale sau cele bivalente (lumină naturală şi electrică).

Prelucrarea luminii naturale în zona ferestrelor sau înaintea lor a devenit azi o preocupare care s-a transformat în soluții de la bune la foarte bune, în funcție de structurile studiate şi care au fost brevetate în Italia, Elveția, Germania ş.a.

2 STRUCTURI CENTRALE ŞI LATERALE MODERNE PENTRU TRANSFERUL LUMINII NATURALE ÎN CLĂDIRI MEDII ŞI MARI

Structurile centrale de transfer al luminii naturale s-au realizat şi se realizează azi în trei-patru moduri (Figura 3), descrise în continuare:

— Prin zonă centrala relativ îngustă şi cu transmisie a luminii naturale prin fascicule concentrate şi dirijate prin oglinzi de la un captator exterior orientabil automat către sursa solară sau cu mai multe captatoare fixe pentru diversele poziții ale incidenței solare.

— Prin zonă centrală medie ca dimensiuni de tip atrium (curte interioară), dacă clădirea nu are multe/foarte multe niveluri, fără prelucarre specială a luminii naturale.

— Prin zonă centrală mare ca dimensiuni (de tip atrium mare) când sunt multe/foarte multe niveluri şi fără prelucrarea specială a luminii naturale.

— Prin zona centrală mare cumulat şi cu o zonă laterală vitrată (rar două) la multe/foarte multe niveluri şi de asemenea fără prelucrare specială a luminii naturale.

— Prin zone laterale la clădiri mari sau parțiale pe anumite zone de interes.

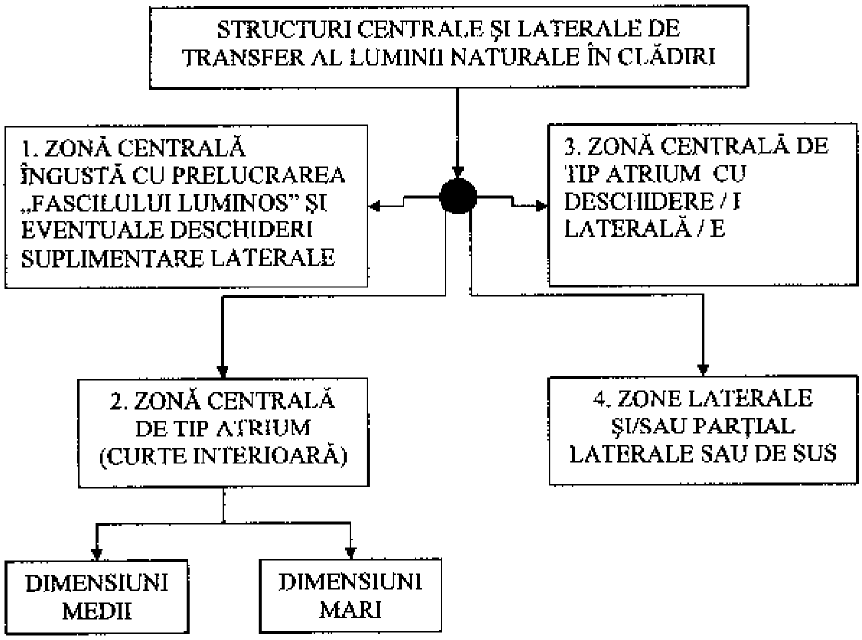

Figura 3 Moduri actuale de transfer al luminii naturale în interiorul clădirilor

În Figura 4 se poate urmări o structură modernă realizată de PHILIPS cu aport de lumină prin zona centrală dar şi laterală la o clădire mare-foarte mare destinată birourilor.

Figura 4 Clădire cu aport mare-foarte mare de lumină de sus şi lateral

3 NOUA GENERAȚIE DE STRUCTURI COMPACTIZATE PENTRU SISTEMELE DE ILUMINAT INTEGRATE AFERENTE CLĂDIRILOR MODERNE

Chiar dacă tubul de lumină a fost inventat în 1881, el a devenit operațional în deceniul al IX-lea al secolului trecut datorită profesorului Whidhead (U.K.) şi companiei 3M care a dezvoltat şi fabricat produsul echipat pentru lumina electrică exclusiv cu surse de înaltă calitate PHILIPS LIGHTING.

O altă variantă recent dezvoltată în Anglia este tubul solar de dimensiuni mult mai mari şi care, în mod fericit, se poate integra şi cu o ventilare naturală pentru anumite spații.

În continuare vor fi tratate cele două structuri menționate (Figura 5), care pot avea alimentare monovalentă (o singură sursă de lumină) sau bivalentă (două surse de lumină: naturală şi electrică). Menționăm că propunerea funcționării bivalente a tubului solar, cu sursă de lumină electrică înglobată pentru seară/noapte, este o idee originală a autorilor acestei lucrări[1]. De asemenea la tubul solar se poate realiza o integrare cu ventilarea naturală.

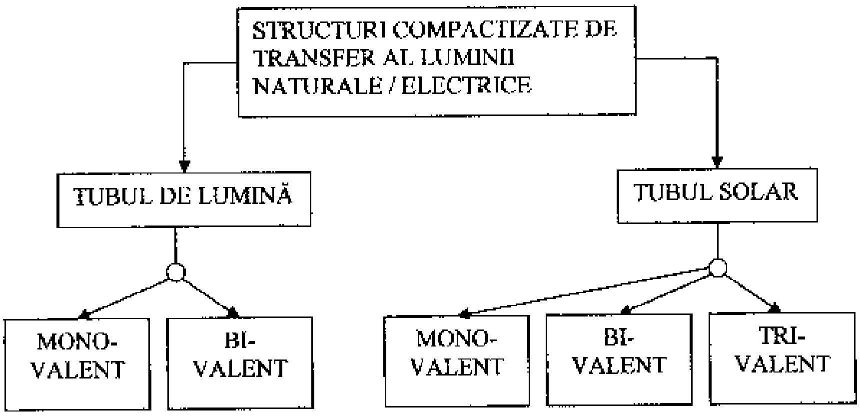

Figura 5 Structuri compactizate de transfer al luminii

3.1 Transferul luminii naturale în interiorul clădirilor prin tuburi de lumină

Tubul de lumină reprezintă o sursă secundară care transferă lumina de la o sursă primară (electrică sau naturală) fie într-o anumită încăpere, fie la un anumit obiectiv, fie pe o anumită zonă/suprafață (reflectantă sau transmițătoare) pentru realizarea sistemului de iluminat necesar desfăşurării unei activități. Transmisia luminii se poate realiza fie la capătul tubului, de unde aceasta este distribuită şi orientată, în funcție de necesitățile obiectivului, fie pe parcurs prin transfer lateral către obiectivele dorite.

Tubul de lumină transmite radiația luminoasă în interiorul său pe baza reflexiei interne totale produse prin structura filmului optic de 0,5 mm grosime (SOLF – Scotch Optical Lighting Film – produs de compania 3M) realizat din acril sau policarbonat transparent. Suprafața exterioară a filmului are o structură prismatică, necesară reflexiei totale, iar cea interioară este plană. Filmul optic este acoperit de un tub de protecție de 25 mm diametru ce se montează perfect pe acesta.

În continuare se descrie o structură monovalentă de transfer al luminii naturale (exclusiv) într-o clădire.

Principiul sistemului este prezentat în figura 6 în care se poate urmări o schiță a unei clădiri în care lumina naturală este receptată prin captorul 1 şi se transferă din coloanele 2 şi 3 la fiecare nivel prin tuburile 6 şi 7 în zona centrala si prin 4, 5 în zona de activitate. Astfel se satisfac, printr-un sistem mult mai comprimat fizic, cerințele de completare eficiente şi economice ale nivelului de iluminare cerut de diverse încăperi ale clădirii, pentru o uniformitate corespunzătoare asigurării echilibrului mediului luminos capabil să îmbunătățească confortul vizual necesar.

În Figura 7 se poate urmări o clasificare a sistemelor de iluminat integrate bivalente cu tuburi de lumină pe baza unei idei originale de integrare prin utilizarea surselor de lumină naturală şi electrică amplasate diametral opus, acționând astfel:

- când nivelul emisiei sursei naturale scade, intra în funcțiune sursa electrică cu flux reglabil şi cu rolul de menținere a nivelului de iluminare;
- când nivelul emisiei naturale a scazut la zero (seară/noapte), sursa electrică va asigura nivelul de iluminare necesar.

[1] Se pare că ideea a apărut recent şi pe plan mondial

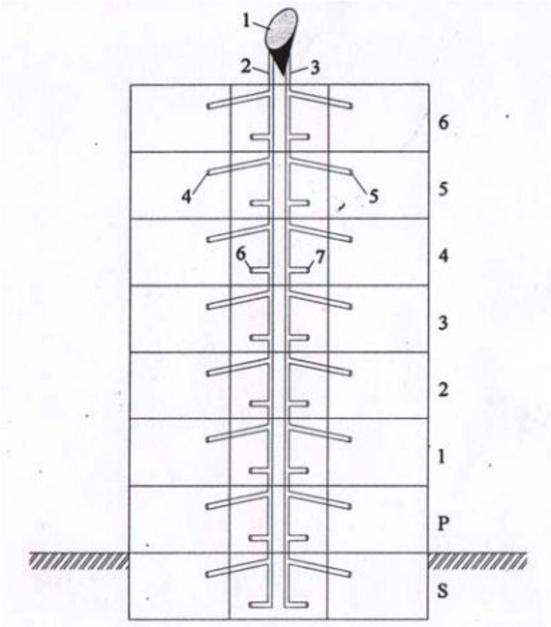

Figura 6 Principiul transferului luminii naturale în interiorul clădirilor cu ajutorul tuburilor de lumină prin zona funcțională, printr-o structură monovalentă:

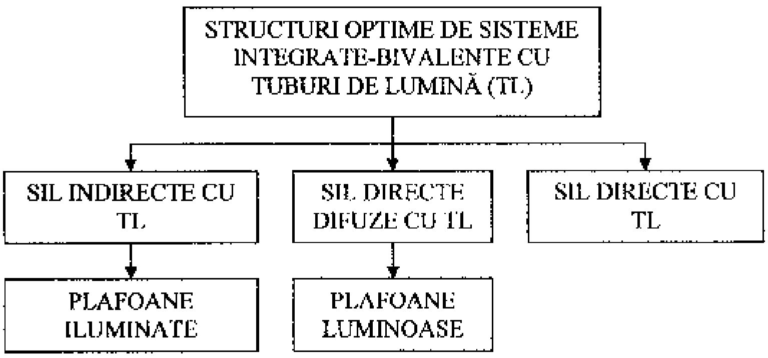

Figura 7 Structuri bivalente cu tuburi de lumină destinate iluminatului natural şi electric pentru clădiri

Ca surse de lumină electrice pot fi utilizate cele mai eficiente dintre acestea, cum sunt de exemplu lămpile cu descărcări de vapori de mercur la înaltă presiune şi cu adaosuri de ioduri metalice – MH Philips, alese la o temperatură de culoare neutră/ neutru cald/ neutru rece, în funcție de destinația încăperii. Dacă se doreşte „meținerea psihologică" a luminii de zi, atunci orientarea va fi către neutru rece. Astfel, se pot utiliza următoarele surse:

- MHN-TD – neutru rece (Tc=4200 K) cu redare bună către foarte bună a culorilor (Ra=85) şi eficacitate luminoasă de 70 lm/W;
- MHW-TD – cald (Tc=3000 K) cu redare bună (Ra=75) şi eficacitate luminoasă 75 lm/W şi/sau CDM cu caracteristici similare.

În 1998-1999 autorii au propus sistemul bivalent integrat indirect descris mai departe, soluție excelentă pentru interioarele destinate exclusiv activității la calculatoare personale prin evitarea reflexiei de voal şi menținerea permanentă a mediului luminos confortabil. De asemenea sistemul poate fi utilizat pentru alte încăperi care necesită acest tip de iluminat (de exemplu muzee ş.a.).

În Figura 8 se poate observa schema sistemului original propus.

Sistemul bivalent poate fi utilizat şi pentru plafoane luminoase echipate în interior cu tuburi de lumină, de asemenea o idee originală.

3.2 Transferul luminii naturale în clădiri prin tuburi solare

O variantă nouă a tubului de lumină a fost realizată şi promovată în Anglia, țară în care există o preocupare deosebită pentru utilzarea luminii naturale atât în interiorul clădirilor noi, cât şi a celor vechi reabilitate.

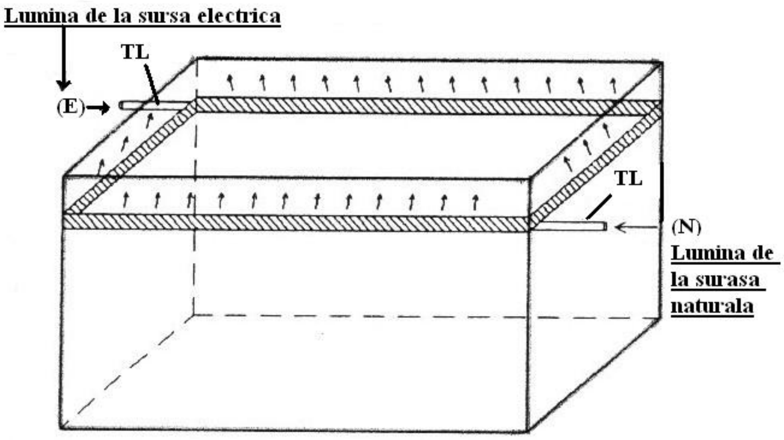

Figura 8 Schema unui sistem de iluminat integrat bivalent indirect cu tuburi de lumină TL

Structura noilor tuburi de lumină solară este diferită față de a celor prezentate anterior, în primul rând prin dimensiuni şi anume:

- diametre mult mai mari (~10-20 ori față de tuburile clasice prezentate);
- lungimi mult mai mici, fiind concepute în general pentru transferul luminii la clădiri de înălțime mică.
- transferul realizat prin reflexie interioară în tubul de aluminiu supra-argintat.

În Figura 9 se poate urmări structura unui tub solar monovalent de transfer al luminii în interior cu o structură rectilinie.

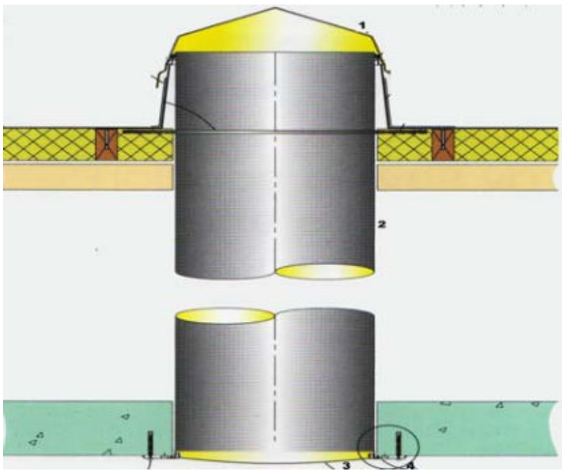

Figura 9 Tub solar monovalent rectiliniu:
1 – capac transparent din policarbonat cu protecție la radiații UV; 2 – tubul din aluminiu super-argintat; 3 – panou circular difuzant; 4 – prindere sigură de structura plafonului

În Figura 10 se poate urmări un sistem bivalent realizat în Anglia cu două componente diferite, dar structurate şi coordonate în ansamblu:

- transferul luminii naturale/solare în clădire;
- ventilarea naturală de zi/noapte controlată.

Cele două sunt realizate cu un sistem integrat de transfer lumină şi aer, compactizat şi controlat.

Sistemele bivalente (utilizarea pe aceeaşi structură a luminii naturale/solare şi a luminii electrice), precum şi cele trivalente (lumină naturală/solară, lumină electrică şi ventilare naturală controlată) sunt idei originale ale autorilor acestei lucrări, dar care la ora actuală se pare că au apărut şi pe plan mondial în varianta cu cele două surse de lumină.

Sperăm că în viitorul apropiat să putem experimenta şi promova şi aceste structuri datorită avantajelor ce le prezintă, evident după găsirea unei soluții tratate, studiate şi experimentate privind ulltima parte a transferului luminii în încăpere pentru cele două surse diferite (naturală şi electrică).

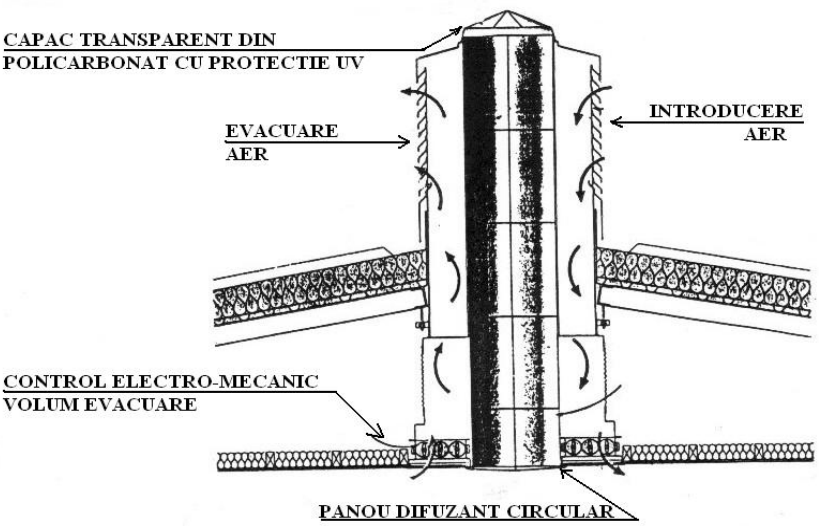

Figura 10 Structura unui sistem bivalent: transfer lumină naturală/solară cu ventilare naturală controlată

4 CONCLUZII

Lucrarea de faţă a tratat aspecte actuale privind iluminatul în sistemul energetic clădire, analizând ultimele sisteme şi structuri pentru transferul luminii naturale în clădire şi a combinaţiei integrării permanente dintre lumina naturală şi electrică capabilă să asigure permanent şi constant un mediu luminos confortabil.

Sperăm ca în viitorul apropiat să reuşim şi în România introducerea tuturor sistemelor moderne integrate într-o structură inteligentă în aşa fel încât în fiecare clădire, indiferent de destinaţia sa, să se obţină un confort maxim, permanent, constant ca parametri ai mediului luminos, cu un consum energetic minim, pe baza aspectelor determinante prezentate în cele două lucrări.

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FROM ROAD LIGHTING TO CITY BEAUTIFICATION

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SUMMARY

True city beautification with lighting is not an isolated affair. Residential area lighting, road lighting and the aesthetically pleasing lighting of buildings, monuments and structures should be integrated in one overall master plan for an area or city. The final result should have a positive effect on the image created of the area. Image here is important for both visitors (outwards orientation of image) and residents (inwards orientation of image). The effect lighting has on both visitors and residents has much to do with emotion. The paper shows that the creation of the right emotion is directly connected with the appropriate use of dark and light, with the appropriate use of natural white light on the one hand and coloured light on the other hand and with carefully applying dynamic lighting. Guidance is given on how all this can be done while minimizing light pollution.

INTRODUCTION

At the start of the 20th century, outdoor lighting was geared towards the purely functional aspect of visibility for motorists. In the fifties of the same century, de Boer was one of the first researchers to add visual comfort to the pure visibility aspect of road lighting [1]. This comfort aspect was felt to be important in view of the fact that high-speed road users were already making use of relatively comfortable motorways for rather long drives: again, traffic safety was the underlying criterion. However, this attention to visual comfort automatically made new road lighting installations more pleasing. So, up until the late seventies of the last century, road lighting, including that within the urban environment, was seen mostly in the context of motorised traffic. One of the first systematic studies into the needs of residents and pedestrians in residential streets, with the emphasis on personal or social security, was carried out by Caminada and van Bommel and published in 1980 [2, 3]. They concluded that in order to provide good security, the lighting in a street should permit of mutual recognition of pedestrians at a 'safe' distance, viz. before coming almost face to face.

It was only slowly that the architectural aspect of outdoor lighting started to receive some attention in addition to the functional aspects of traffic safety and social security. Today we are seeing a clear shift of focus towards our general "well-being" or "quality of life". Seen in this context, it is not surprising that we are now seeing so much interest in lighting as a means to enhance the visual outdoor environment. During the hours of darkness, the visual environment can be "recreated" with lighting. And while this lighting can simply be designed to almost reproduce the daytime situation, it is often more interesting and challenging to create an entirely "new" night-time scene.

Lighting can be used as a means to "beautify" the urban night-time environment, and with right we can therefore use the term "city beautification".

True city beautification is not an isolated affair. Residential area lighting, road lighting and the aesthetically pleasing lighting of buildings, monuments and structures should be integrated in one overall master plan for an area or city. The final result should have a positive effect on the image created of the area. Here image has both an outward and an inward aspect. The outward aspect of image is related to the creation of a pleasing effect on visitors to the area. That is to say the lighting helps to promote the area, and so attract visitors, so it has a commercial value. The inward aspect of image is related to the way the lighting affects the residents themselves. It serves to give the area an identity all of its own, which can create a feeling of pride in the residents. The effect lighting has on both visitors and residents has much to do with emotion. This means that good city beautification can only be designed if the emotional effects of lighting are properly understood.

LIGHTING AND EMOTION

The presence or absence of daylight, viz. light or darkness, has an important impact on our emotions, which may vary from pleasant to cheerless, even to fear. The “quality” of the daylight also has a strong influence. We usually “feel” better under a sunny sky with strong shadows than under a cloudy, diffuse sky. The emotional impact seems to be an immediate one: we “feel” our mood changing when the sun comes out, and children immediately become fearful when they step into the dark. Artificial light can have similar emotional effects, and this holds true both for indoor and outdoor (night-time) situations. Since contrasts can often be made larger in outdoor environments because the dark sky usually forms the background, we can more easily create strong emotional effects with outdoor lighting than with indoor lighting. Figure 1 illustrates what outdoor lighting can do with our emotions. It shows two photographs of the same church lit in completely different ways.

Figure 1 Same church with different lighting, resulting in two completely different emotional feelings.

The point here is not that the situation depicted in one of the photographs is any better than that in the other, but rather the fact that we tend to experience two completely different feelings. The church on the left we see as being “pleasantly lighted”, whereas that on the right is much more likely to be described as being “scary”.

In these photographs the different effects are obtained by greatly different light-dark contrasts. Another technique that can be used to “play” with our emotions is the use of certain “shades’ of white light. From interior lighting we know that lamps with low colour temperatures (warm-white light) result in a different subjective appraisal than that produced by lamps with high colour temperatures (cool-white light). In road and street lighting, the use of yellow-white (sodium) light has a different emotional meaning to that associated with the use of “whiter” light. The use of saturated coloured light in the outdoor environment has a different emotional effect again. What we especially like about daylight is its dynamic character, viz. the quantity and composition of the light (direction, shadows, colour, clearness and diffuseness) change continuously, especially on sunny days. Dynamic artificial lighting is another technique that we can use to create strong feelings about the night-time environment.

Light and dark

“Light and dark” has two elements in it: the general lightness or darkness and the contrasts between light and dark parts. For example, the church shown on the left in Figure 1 is far lighter than that on the right. This in itself has an emotional effect. But the real dramatic effect of the situation on the right has much more to do with the fact that we have here very large contrasts between the light and the dark parts. Of course, we should realise that while large contrasts produce strong emotional effects, they can also mask very charming details. It is therefore of the utmost importance that the designer and his client get together at the outset of an illumination project to carefully decide exactly what effects are really wanted. For good recognition, the direction of light incidence on interesting details should be such that the soft shadows created emphasise the three-dimensional character of these, which in their turn will help to create additional emotional effects. Too often we see that buildings and monuments are simply “flooded” with bright light, without producing any shadows or contrasts. In fact the church shown on the left in Figure 1 is an example of this. The building depicted in Figure 2, on the other hand, has carefully designed shadows, and lighter and somewhat darker parts create an agreeable and interesting picture that invites the observer to explore further. These photographs also illustrate that a high brightness alone is certainly no guarantee of an acceptable end result – on the contrary, it actually increases the chances of light pollution (see Section on Light Pollution).

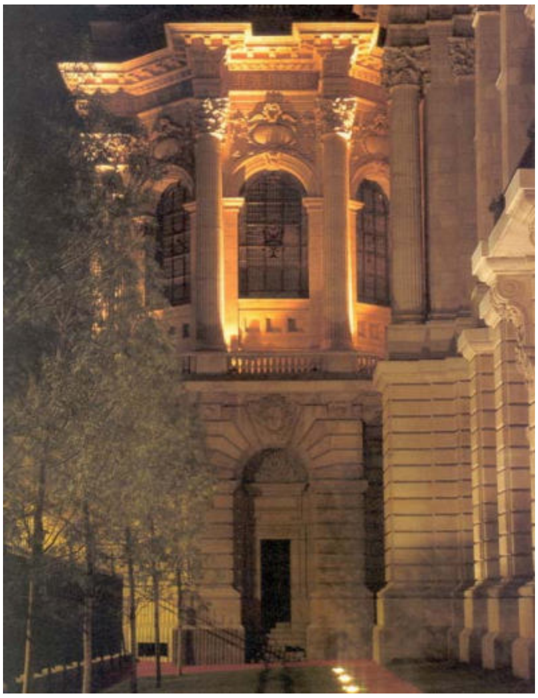

Figure 2 Subtle use of shadows and soft light, alternated with somewhat darker parts, invites further exploration.

Whiter light

At the World Exhibition in Paris in 1881, the new incandescent lamp was introduced to a wide public. Slowly, incandescent lamps took over from gas lighting. Both types of lighting combine a very good colour rendering with a white colour appearance. Until 1932, no new electric light sources were introduced, which meant that the world became accustomed to a white night-time outdoor environment. In that same year, the first gas discharge lamp was used in an installation. This, the low-pressure sodium lamp, became a very economical (today more than 175 system lm/W - see Figure 3) and technically good solution for use in road lighting. In 1932 a second gas discharge lamp, the high-pressure mercury lamp, was introduced. Whereas the low-pressure sodium lamp “coloured” the outdoor environment in shades of yellow, colour rendition being non-existent, the much less efficient high-pressure mercury lamp (maximum 60 system lm/W - see Figure 3) offered the possibility to have the outdoor environment lit with white light. These lamps, in spite of their poor colour rendering (R_a of 40) were therefore widely used in built-up areas. Nonetheless, more economical light was called for in road lighting, particularly in built-up areas. The answer was the high-pressure sodium lamp, introduced in the late nineteen sixties. This lamp combines moderate colour rendering (R_a in the 20-ties) with yellow-white light with a very good efficacy (between 100 lm/W and more than 120 system lm/W – see Figure 3) and a long, reliable lifetime. After the energy crisis in the early nineteen seventies, this yellow-white lamp became the standard in road lighting in built-up areas. As a consequence, it now “colours” our night-time outdoor environment yellow-white.

Only small, minor roads where low lighting levels are accepted are sometimes lit with white compact fluorescent lamps developed after the energy crisis (system lm/W around 75 – see Figure 3). The white colour of these outdoor environments is much appreciated, probably because it evokes a positive emotion. What was needed, however, was an efficient, reliable source of white light capable of lighting whole built-up areas in this natural white light. So far, the metal halide lamp, an efficient version of the mercury discharge lamp with metal halide additives, resulting in white light of good colour rendering, has not yet provided the answer. This is because compared with sodium lamps, the lifetime of metal halide lamps was not good enough to replace the former in road lighting. The same metal halide lamp does, however, produce good results in sports stadiums and other floodlighting installations, where the hours of use per year are much less than in road lighting. Luckily, however, in this very year 2005, a special revolutionary version of a metal halide lamp is being introduced that will enable the world to turn its yellow-white outdoor environment back into natural white! This lamp, the Cosmopolis, draws on high-pressure sodium techniques and has a specific dose of certain metal halides. It combines high efficacy (at its introduction, more than 100 system lm/W – see Figure 3) with a long, reliable life approaching that of high-pressure sodium lamps (90 per cent survival rate at 12 000 – 16 000 hours). The 140 W version has an even higher efficacy than that of the 150 W high-pressure sodium lamp! Further efficiency improvements are obtained because of the compactness of the lamp, resulting in a better optical performance in luminaires. It can be expected that this new lamp type will indeed dramatically change the appearance of our night-time outdoor environment [4]

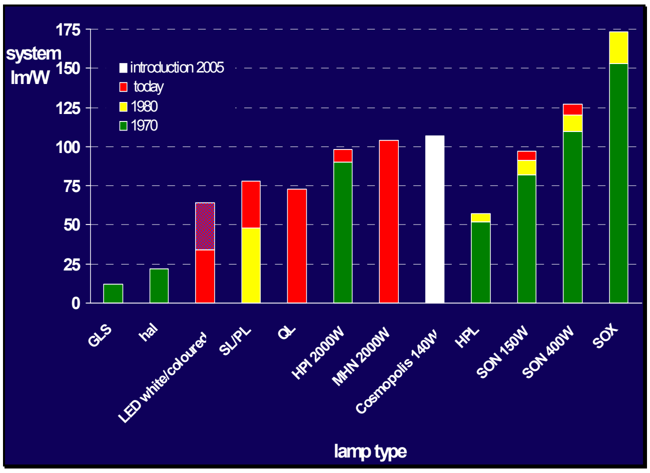

Figure 3 Luminous efficacy of lamps employed in outdoor lighting (efficacies based on wattages typical for outdoor lighting applications)
GLS = incandescent lamp
Hal = halogen lamp (for flood lighting)
LED = light-emitting diode (solid-state light)
SL/PL = compact fluorescent lamp
QL = long-life induction lamp
HPI = metal halide lamp (for flood and sports lighting)
MHD = single bulb metal halide lamp (for flood and sports lighting)
Cosmopolis = new type of metal halide lamp (introduction 2005)
HPL = high-pressure mercury lamp
SON = high-pressure sodium lamp
SOX = low-pressure sodium lamp

Coloured light

It is interesting to note that the use of coloured light for the floodlighting of buildings and monuments seems to be dependent upon past experience and cultural background. In Asia, coloured light has always been an instrument used to give extra emphasis to the floodlit object, with rather saturated colours often being employed. In America and Europe, the use of coloured light is more recent, and especially in Europe, somewhat softer colours are often used. It should be noted here that different colours sometimes have different emotional responses in different parts of the world.

Coloured light can have a strong impact on the object itself, but also on the whole of the night-time environment. Careful discussions with the owner of the object being lighted on exactly what effects are wanted and what the possible consequences may be for the neighbourhood are very important in order to avoid disappointments or problems with other users of the neighbourhood.

Until recently, colour filters attached to conventional light sources were mostly employed to produce coloured light. But coloured metal halide lamps that emit coloured light have now become available. These give saturated colours more efficiently because no filtering is required. Light-emitting diodes (LEDs) or solid-state lights have already been in use for some years for coloured ornamental, festive or advertising lighting. Here the goal is that the eyes of the observer look straight into the light source (in a way, a kind of “signalling” lighting), which means that relatively low-power LEDs can do the job. High-power LEDs have now been developed with such high lumen packages and efficacies (see Figure 3) that they can be employed for real floodlighting of objects. They are available in many different colours, and in white as well, and have long lifetimes and can be easily regulated in light output between 100 and 0 per cent. LED luminaires for floodlighting purposes consist of an array of many individual LEDs that all have there own tiny reflector. With these small optical units, narrow light beams can be obtained that were once impossible. Figure 4 shows a typical LED-line luminaire with a near-parallel beam. Thanks to this narrow beam, floodlighting installations can now be produced where the luminaires themselves are positioned very close to or against the object being lighted. This offers a unique possibility to create special effects because the grazing light incidence enhances any unevenness of the construction material, and thus the character of it. Installation of the installation is usually easier and more economical, and it can be more easily maintained.

Figure 4 Near-parallel beam of LED-line

Figure 5 Example of an installation where LED-lines are placed against the lighted area itself.

Furthermore, the risk of producing disturbing light pollution is minimised. Figure 5 shows an example of an installation where LED-lines are placed against the lighted chimney itself.

Dynamic Light

One of the many qualities that are so much appreciated with daylight is that it varies so much. It is, in a word, dynamic. It is therefore not surprising that dynamic lighting is also being employed in city beautification. For festive and advertisement lighting, successions of rapid changes in colour and brightness are used, the aim being to attract the attention of passers-by.

LEDs are very suitable as sources of dynamic light: they are easy to regulate, and allow mixing of different colours to creation a wide variety of effects using a relatively simple technology. The extremes here are the LED video screens that can have enough brightness to be used even during the bright hours of daytime. A far more subtle use of dynamics in lighting is the slow and gradual change of brightness and or colour. This often “invites” the observer to explore the object and its changing visual impression further. We are seeing more and more examples of where these kinds of dynamic light changes are also used as a means to communicate. The communication message can employ a change of brightness and or colour pattern to indicate the time, the temperature, the weather forecast, and even whether or not a facility is open. And it is not beyond the bounds of possibility that residents, working together, could influence the lighting of the object(s) concerned via their neighbourhood internet.

LIGHTING AND THE RESTRICTION OF LIGHT POLLUTION

City beautification can give rise to obtrusive light, which is defined as light where it is not wanted and not needed. Obtrusive light is spill light, and as such it has direct negative consequences for the efficiency of the installation. More importantly, it can evoke strong negative emotions and have adverse effects on traffic safety. And the “disappearance” of the night sky because of sky glow interferes with both amateur and professional astronomical observations. All this is often referred to as “light pollution”.

Fortunately, these negative side-effects of city beautification lighting installations can be avoided, or at least minimised, by a combination of technical and organisational methods. To this end, in 2003 the CIE produced a “Guide on the limitation of the effects of obtrusive light from outdoor lighting installations” [5]. If the recommendations set out in this Guide are applied correctly, it is possible to not only minimise the amount of “spilled” light, but also to actually increase the efficiency of the installation concerned. The Guide gives restrictive values for different photometric parameters resulting from the installation, the most important of which are: vertical illuminances on neighbouring properties, maximum luminous intensities for luminaires in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, and upward light ratios to limit sky glow. All limits are dependent upon two different aspects:

- The level of brightness already existing in the area (in the CIE Guide called “lighting environment”)
- The time (in the evening or night) that the lighting is to operate.

If the brightness of the environment is low, the risk of producing disturbing obtrusive light is high, and consequently the illuminance and intensity limits are stricter. In brighter surroundings, the risks are lower, because the contrasts between any possible obtrusive lighting and the bright surroundings are smaller, so the limits are therefore also less strict. Four different categories or zones of lighting environments are defined as E1 to E4 and given in Table 1. Stricter limits are given for the lower E zones.

Table 1 Environmental lighting zones

Zone	Surrounding	Lighting environment	Examples
E1	Natural	Intrinsically dark	National parks or protected sites
E2	Rural	Low district brightness	Industrial or residential rural areas
E3	Suburban	Medium district brightness	Industrial or residential suburbs
E4	Urban	High district brightness	Town centres and commercial areas

In order to achieve a proper balance between the interests of the “users” of the lighting on the one hand and those of the residents on the other, two sets of limiting values (see above) are given for each situation: one with higher (viz. less strict) values for use before a “curfew” hour and the other with lower (stricter) values for use after that curfew hour. The relevant authorities should set the exact time of the curfew hour.

CONCLUSION

The effect that city beautification lighting has on both visitors and residents has much to do with emotion. The lighting should, and can, be aimed at giving rise to positive emotions. For this a deep understanding of the underlying causes, some of which are dealt with in this paper, is essential. The negative emotional effect of obtrusive light should, and can, be avoided by following the guidelines set out in a recent CIE Publication on obtrusive light [4]. New developments in this respect should be followed, because new research on this subject is being carried out that will probably lead to further and refined rules [5]. A wealth of new products, such as LEDs and new, innovative metal halide lamps, together with more compact luminaires, offer totally new possibilities for city beautification, thus helping to make our night-time environment one that fits in with our endeavours to achieve a better quality of life.

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TOWARDS DESIGN CRITERIA FOR DAYLIGHT GUIDANCE SYSTEMS

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ABSTRACT

Tubular daylight guidance systems (TDGS) are linear devices that channel daylight into the core of a building. CIE 173:2006 offers guidance on some design issues but does not specify the design criteria necessary to achieve satisfactory user conditions. This work addresses this problem using field studies of working buildings lit by daylight guidance. Data on achieved lighting conditions, and user views on quantity and quality of the lit interior, were gathered and statistical techniques used to link the two data sets. Results show daylight contributions of the order of 25% of total design workstation illuminance with daylight factors ranging from 0.2% to 1.6%. User views suggest that TDGS were inferior to windows in delivery of both quantity and quality of daylight. Guidelines for design of future systems are suggested.

Keywords: offices, lighting, daylight, guidance systems, light pipes, costs, benefits

1 INTRODUCTION

Tubular daylight guidance systems (TDGS) are linear structures that channel daylight by means of optical interactions into the core of a building. The development, over the last decade, of materials with high specular reflectance has led to a large number of passive zenithal systems, the most commercially successful type, being installed in many parts of the world. Passive zenithal tubular daylight guidance systems consist of a clear polycarbonate dome that accepts sunlight and skylight from part or the whole sky hemisphere; a rigid or flexible tube lined with highly reflective material to redirect the light; and light output devices, commonly diffusers made of opal or prismatic material or an array of Fresnel lenses.

There has been a considerable research effort on TDGS over the last decade. Initially this concentrated on light transport materials and devices but latterly a number of methods of predicting light delivery and/or distribution within a building interior have been developed which form the basis of CIE173:2006 (1). One major area that has not been researched is design criteria to give satisfactory user conditions. Existing design norms for electric or daylight design have only limited applicability in this respect since TDGS share few physical characteristics with conventional lighting. More fundamentally, although TDGS are sold on the notion of delivering ‘daylight’, there is little understanding of the circumstances under which light emerging from a guide can be regarded as daylight.

This paper reports surveys of achieved conditions in a number of TDGS and an investigation of human response to the systems. These were related to characteristics of the building and its lighting system and permitted investigation of quantity and quality of daylight delivered by the systems and other issues. The rooms were generally large and contained areas where TDGS were the main daylight source. They also offered the opportunity to study the influence of different types of output device, different layouts of output device, and the presence or absence of TDGS in similar areas. This study uses average DPF and DPF at each individual workstation as a measure of daylight penetration. The thirteen offices studied were located in the UK. Two of the TDGS were in new buildings, two were included as part of a complete redesign of building lighting and the rest were retrofitted to existing accommodation. The offices were mainly open plan (average area of 257m^2 , room index from 1.76 to 5.8, average number of users 17). Seven of the installations were windowless; in four the windows were so remote as to provide no workstation illuminance in the area studied; and the others had small vertical windows. Only 15% of the workstations studied were in rooms equipped with windows. All rooms were equipped with electric lighting (mainly mirrored louvered down-lighters). The guide output devices were circular domed or flat opal diffusers, or 600x600 square lensed panels, all located in suspended ceilings. In the majority of rooms the output devices were in regular arrays over the whole area studied, but in others they lit only part. As the surveys took place in working areas, the data-collection methods were necessarily limited to those that did not interfere with the running of the organisation. Detailed information on room layout, lighting layout and control, window and blind details was collected and an illuminance measurement made at each workstation firstly for a combination of electric lighting and daylight and secondly, if possible, for daylight only. A questionnaire filled in by 168 occupants related to occupants' personal and employment circumstances, daylight in buildings, photometric conditions at workplace, and perceptions of the lit environment. The questionnaire format was either rating scales (1=low effect to 5=high effect) or binary tick box.

2 RESULTS

2.1 Achieved lighting levels

Table 1 summarises the arithmetic average of the measured workstation illuminance values from combined electric lighting and daylight, and that due to daylight alone. It was only possible to measure daylight in three rooms, the daylight contribution in the remaining rooms being estimated using the average daylight penetration factor (DPF) and/or average daylight factor (DF) together with a measured external illuminance. DPF is analogous to DF and is the illuminance received at a point indoors via a light guide expressed as a percentage of the global exterior illuminance. Additionally DPF for each individual workstation from all guides was calculated using the point by point method of CIE 173 and these are shown in Figure 1 (1). It is clear that half of the values are below 0.5% DPF, and only 10% above 1.0% DPF. There were positive correlations between guide aperture area and individual DPF guide aperture area, and between individual DPF and workstation daylight illuminance.

Table 1 Summary of lighting levels in installations

Building	Average illuminance across all workstations (lux)		Daylight apertures as % of total wall or ceiling area		Average work plane DPF+ DF (%)	Output device nadir luminance (cd/m^2)
	Electric and daylight	Daylight only: Measured or *estimated*	Windows	Guides		
1.1	930	211	3	1.9	1.1	5000
1.2	846	410	4	1.4	1.1	8200
4.2	564	*280*	0	0.7	0.4	8200
13	700	*430*	0	2.3	0.8	13000
21.1	932	*128*	10	0.4	1.6	780
21.2	507	*38*	0	0.4	0.26	3900
21.3	567	*160*	0	0.4	0.26	2700
22	332	72	0.5	1.0	0.6	2700
23.1	647	*206*	0	3.2	0.59	4900
23.2	524	0	0	0	0	
23.3	949	*210*	0	4.3	0.6	4900
24.1	279	*70*	6	0.9	0.68	3300
24.2	236	*15*	6 (atrium)	0	0.1	
25.1	372	*150*	0	2.3	0.22	6500
25.2	455	*140*	0	2.2	0.21	6500

About a quarter of the occupants were working below the Society of Light and Lighting (SLL) recommended values for offices (300 - 500 lux) with some 40% above this range (4). Although the daylight systems arguably contribute some over-lighting, only 10% of the workstation daylight levels would on their own satisfy SLL minimum requirements for offices. The daylight contribution generally represents about 25% of total illuminance. The daylight contribution is influenced by a number of factors, notably the lower number of, and light output from, the guides relative to that of the electric luminaires; the distance from workstations to the output devices; and the small size of windows, and distances from windows to workstations. Inspection of Table 1 shows that the number of output devices is between 25 and 50% of the number of luminaires. A typical 600 mm square luminaire has an output of about 5000 lumens. By comparison individual guide output in the installation with the highest recorded external illuminance values was 8700 lumens (Building 4.2) and that for the lowest (Building 22) was 1500 lumens, both estimated using the CIE173 method. In rooms lit by regular arrays of TDGS most workstations were within 2m (on plan) of an output device, but this was exceeded in some cases in buildings 4, 21, 23 and 25. In general window areas in all rooms were either very small or were so far from workstations as to make a negligible illuminance contribution.

2.2 User views of lighting quantity

In terms of lighting quantity around 50% of occupants were satisfied with the amount of light on their workstations with more complaints of too little light than too much. Only about a third were satisfied with the amount of daylight, over 7 times as many preferring more rather than less. No relationships were observed between any of the responses relating to the amount of light and actual levels of total or daylight only illuminance recorded. There is a weak relationship between perception of amount of daylight and both individual workstation DPF and with average DPF calculated using the CIE method, but no relationships between perceptions of total amount of light on workstations and individual DPF. This suggests that DPF in any form is not a reliable indicator of user perception of quantity of light. Users were also asked to assess whether the majority of light on their workstations was daylight. In buildings with windows 40% of users regarded daylight as the main source. In windowless spaces only 7% considered daylight (presumably via the guides) the main illuminator. If the individual DPF values were divided into three groups 0 to 0.499%; 0.5 to 0.999%; and 1.0 to 2.0% (the upper limits of these groups representing the approximate logarithmic scale of equal visual stimulus) the proportion of users regarding daylight as the principal illuminant were 9%, 10% and 33% for the respective groups.

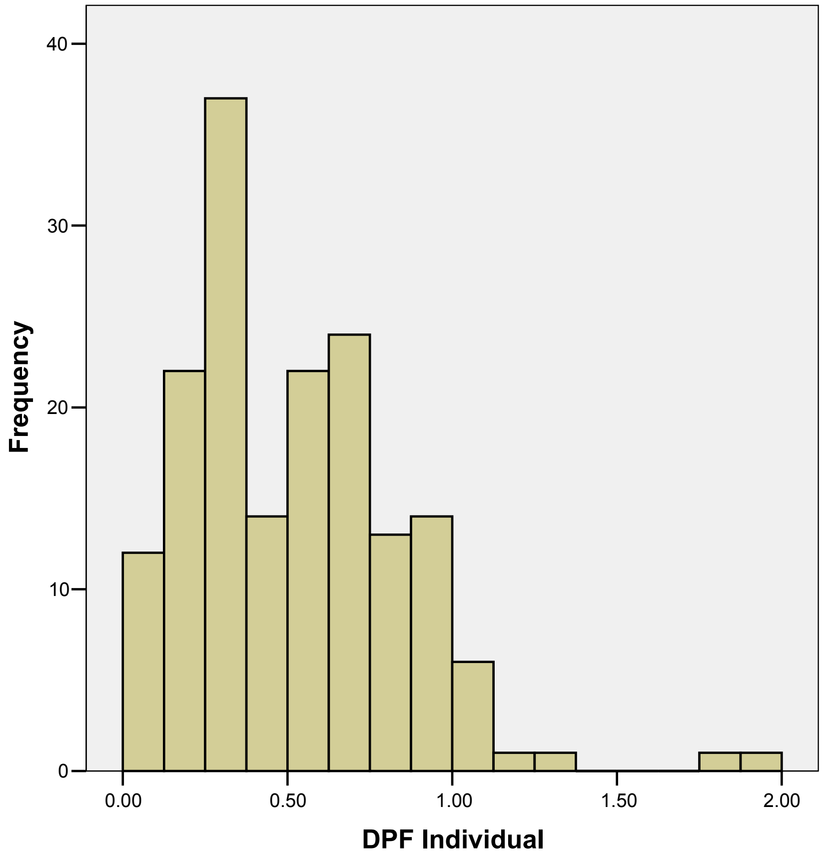

Figure 1 Distribution of individual DPF values

There were statistically significant differences for perceptions of amount of individual workstation daylight between buildings with and without windows, but not for amount of total amount of light. Given that the buildings were deep plan, predominantly electrically lit, with minimal windows this is not surprising.

2.3. User views on lighting quality

The quality of the human visual experience within working buildings is influenced by a number of factors including perception of surface luminance, glare and communication with the external environment. Only 32% liked their visual environment across the whole dataset, 60% in the rooms with windows and 27% in windowless rooms. This suggests that a view of even distant windows has a more beneficial effect on perceptions of lighting quality than that of overhead guide output devices.

About one quarter of users can detect weather and diurnal variation in windowless rooms, presumably by changes in brightness of the guide output devices but the response to the question on external view in windowless spaces suggests that TDGS are not as effective as windows in providing this. Taken together the above suggests that view out is important. Users rated the brightness of the scene in front of them and also that of the ceiling. Figure 2 shows the response to the latter across all visits, that for the scene in front being similar. The majority of users are satisfied with the brightness of the scene in front of them and also that of the ceiling, but the numbers reporting the scene too dim was greater than those reporting too bright. Mean assessments for rooms with windows are close to the neutral point of three, but are much lower in the large windowless rooms. The windows are both of small size and remote from the majority of workstations and thus despite their inability to contribute markedly to surface brightness their absence appears to adversely influence perception of brightness.

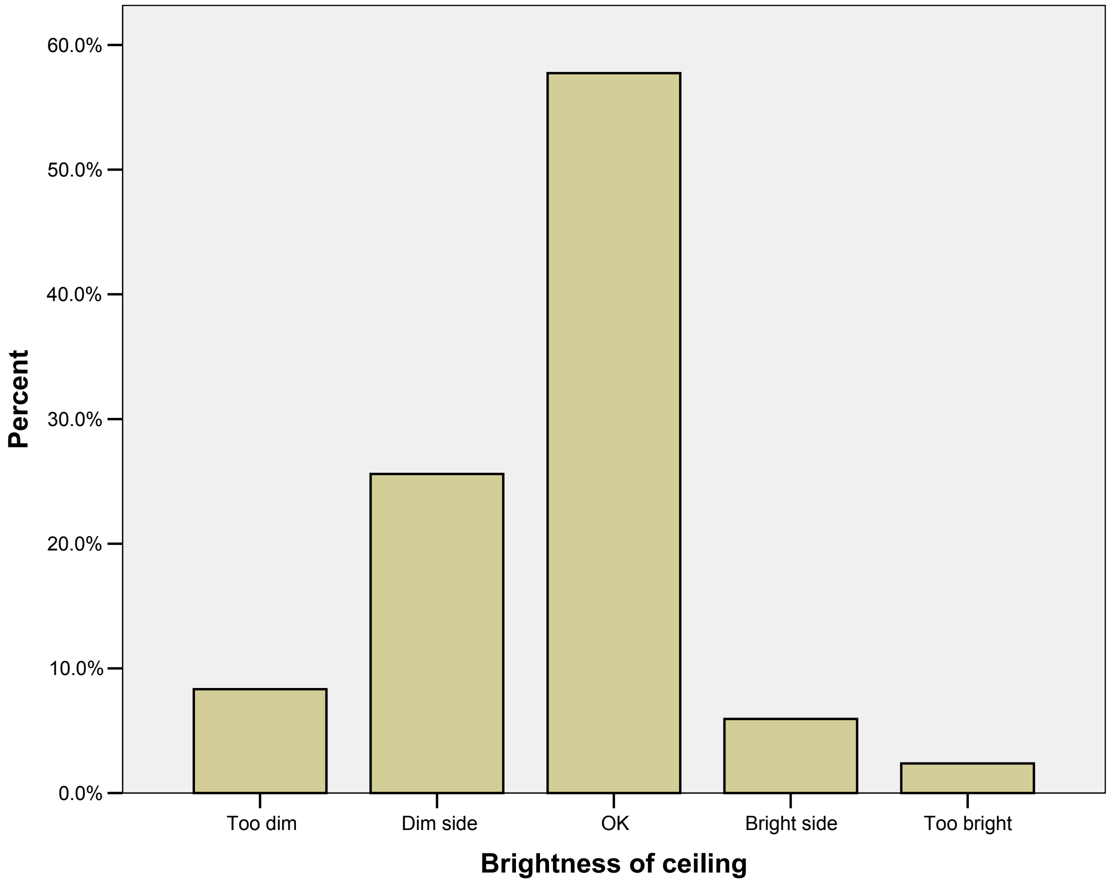

Figure 2 User assessment of brightness of ceiling

The degree of Satisfaction with brightness over all data sets is higher in all cases than the corresponding values for quantity of light. There was no statistically significant difference in glare rating between installations with and without windows. This is consistent with the complaints of too little light on workstations and with the low luminance luminaires and output devices used.

Table 2 shows average responses to the questions on light distribution, light colour, appearance and environmental impact for the whole data set and separately for buildings with and without windows. Although generally rooms with windows performed slightly better, a Mann-Whitney U test showed no statistically significant differences in response with and without windows. This is to be expected given the window configurations and room size. Opinion on shadows tended toward the soft side suggesting that the TDGS moderates the harsh downward modelling of the electric lighting. Given that electric lighting predominated it is perhaps not surprising that the mean answer on distribution of light was close to the neutral point for all cases. Questions on appearance of the light and appearance of user complexion attempted to investigate the colour properties of the installations. Mean response to the two questions was similar with more favourable opinion in rooms with windows. The answers on environmental friendliness of the systems hint that this concept is linked to the provision of windows. The neutral response to whether the systems fit into the room may suggest that the output devices are perceived as similar to luminaires.

Table 2 Mean response and standard deviation of answers relating to on light distribution, light colour, appearance and environmental impact (1 = unfavourable and 5 = favourable)

	Shadows	Distribution	Appear.	Complex.	Environ.	Fits in
Whole set	2.25 *(1.0)*	2.94 *(1.1)*	2.80 *(0.98)*	3.0 *(0.96)*	2.55 *(1.0)*	2.94 (*1.0)*
With windows	2.50 *(1.2)*	3.08 *(1.2)*	3.10 *(1.0)*	3.3 *(0.86)*	3.10 *(1.2)*	3.1 *(1.0)*
Without windows	2.20 *(0.97)*	2.90 *(1.1)*	2.70 *(0.93)*	2.5 *(1.0)*	2.40 *(101)*	2.9 *(1.03)*

The rooms offered the opportunity to study user opinion at workstations located under different layouts of output devices. Luminaires were in all cases located in regular grids across the room area. Some output device grids were of this nature (107 workstations) but in some rooms only part of the area was lit using TDGS (61 workstations). In both conditions only some 30% of users liked the visual environment. A Mann-Whitney U test showed no statistically significant differences in response to questions on perceived amount of daylight, distribution of light or appearance of the room. However there was a statistically significant difference between perception of total amount of light on workstations but this however may be due to a significant difference between the total workstation illuminance in the two cases.

Table 3 Mean response for 'elements of daylight' for each Group DPF. (**Whole data set***,* with windows, without windows*)*

Element of daylight	0 - 0.49% DPF	0.5 - 0.99% DPF	over 1.0% DPF
Amount of daylight (mean)	**1.8,** 2.5, 1.6	**1.9**, 2.2, 1.9	**2.6**, 2.3, 2.7
Time (% answering Yes)	**40**, 81, 31	**24**, 20, 25	**30**, 25, 33
Weather (% answering Yes)	**30**, 81, 18	**39**, 60, 27	**40**, 66, 17
External view (% answering Yes)	**19**, 63, 9	**11**, 40, 9	**20**, 50, 0
Distribution of light (Mean)	**2.8**, 2.8, 2.8	**2.9**, 3.2, 2.9	**3.7**, 2.5, 3.6
Appearance of room (Mean)	**2.6**, 2.9, 2.6	**2.8**, 2.8, 2.8	**3.7**, 3.7, 3.7
Facial appearance (Mean)	**2.8**, 3.1, 2.7	**3.1**, 3.0, 3.1	**3.4**, 3.6, 3.0

Circular flush or dished devices lit 97 workstations, the remainder lit using square devices giving similar total or daylight-only illuminance conditions in the areas lit by both types. Generally square output devices were rated more favourably than circular versions, but particularly total workstation illuminance was perceived to be higher for similar physical conditions. This may be because the square device resembles a luminaire.

2.4 The components of 'daylight'

The popularity of daylight is due its ability to deliver light of high illuminance with spatial and temporal variation, good spectral composition, and also contact with the exterior and a view. Table 3 shows responses for grouped workstation DPF for the whole data set, and split with and without windows. The perception of the main 'components of daylight' was studied with increase in DFP and, unsurprisingly, perception of amount of daylight increases, as does assessment of colour, evenness of the lighting and detection of weather changes. There is no increase in perception of external view or diurnal variation which suggests that even the largest TDGS aperture areas are inferior to windows in these respects.

2.5 Comparison of areas with and without TDGS

Buildings 21, 23 and 24 offered the opportunity to compare similar areas lit solely by electric lighting with those additionally containing TDGS. There were 49 users in areas with TDGS (mean workstation illuminance = 511 for total illuminance, and 130 for daylight-only), and 31 workstations in areas without TDGS (mean workstation illuminance = 371 for total illuminance, and 23 for daylight-only). There were significant differences in both total and daylight-only workstation illuminance between the areas suggesting that the daylight contribution from the TDGS had a marked effect. However a Mann-Whitney U Test only showed a statistically significant difference in perception of evenness of light distribution with rooms with guides appearing more evenly lit.

3 DISCUSSION

The contribution of daylight (average DPF across all rooms 0.65%) was in most cases about 25% of total workstation lighting but was up to 50% of electric lighting illuminance. The disparity in 'installed load' meant the electric lighting was the dominant. Many of the rooms were surveyed on days when external illuminance values were low so that there is potential for substitution of daylight for electric light. The absence of daylight linking allowed diurnal variation to increase illuminance above electric lighting design values but prevented energy savings even when daylight was capable of satisfying SLL requirements. This unsatisfactory result may be due to either the scheme designers deliberately trying to create predominantly electrically-lit spaces with TDGS as a palliative, or a failure to create a day-lit space because the technology was not fully understood or appropriate design guidance available.

Daylight penetration was quantified using the methods described in CIE 173 and the main metrics used were average workplane DPF and DPF at individual workstations. Although the various DPF measures were reliable tools for calculating quantity of daylight illuminance, they proved less reliable indicators of user perception of quantity of daylight.

Some 40% of users in rooms with windows thought that the majority of light on their workstations was daylight, falling to 7% in windowless spaces. Even on workstations where average DPF was above 1.5% only 33% of users regarded daylight as the main source. Installations with or without windows differed significantly in terms of perceptions of amount of daylight and dissatisfaction with daylight, but not for amount of, or dissatisfaction with, total amount of light. Given the predominance of electric lighting and the small windows this is not surprising. Comparison of the results on questions on lighting quality with those described in Reference 3 is interesting. In terms of liking the visual environment the present results agree with the previous study for rooms with windows. For windowless rooms the results are markedly worse suggesting that a view of even distant windows has a more beneficial effect on perceptions of lighting quality than the output devices. About one quarter of users could detect diurnal variations in windowless rooms, presumably by changes in brightness of the guide output devices. The responses to questions on external view, detection of weather and diurnal variation in windowless spaces further confirms that TDGS are not as effective as windows in providing these, and that view out is important. The majority of users were satisfied with brightness conditions but the number reporting the scene too dim was greater than those reporting too bright. The mean assessments were low in the large windowless rooms but not those with windows. Thus despite their inability to contribute markedly to surface brightness the absence of windows appears to adversely influence perception of brightness. There are few reported problems with glare which is consistent with both the low levels of illuminance and the type of lighting equipment used.

The investigation of user response to different output device grid configurations was inconclusive. Both were only liked by 30% of respondents and the only major difference, that of perception total illuminance, may be accounted for by differences in workstation illuminance. Generally square output devices were rated more favourably than circular with total workstation illuminance being perceived to be higher for similar physical conditions. This may be because the square device resembles a luminaire. Perception of the main 'components of daylight' was studied with increasing DFP. Unsurprisingly perception of amount of daylight increases, as does assessment of colour, evenness of the lighting and detection of weather changes. There is no improvement in perception of external view or diurnal variation with increasing DPF suggesting that even the largest TDGS aperture areas are inferior to windows in these respects. The study of similar areas equipped or otherwise with TDGS showed significant differences in physical conditions but, with one exception, no differences in user perception of quality issues. The addition of TDGS in a deep plan office thus appears to only marginally increase user perception of lighting quality.

The results so far confirm that user perception of lighting quality in TDGS improves with increasing daylight penetration. It is hypothesised that a DPF approaching 2% may provide a 'well day-lit space' corresponding to that provided by 2% daylight factor using conventional glazing. This study provides the opportunity of investigating what this proposition would mean in practice for a large open plan office. In Building 22 the actual configuration is a regular array of 40 No. 500 mm diameter output devices at an SHR of 4.3 giving an average DPF of 0.6%. A 2% average DPF would require a regular array of 80 No. 650 mm diameter devices at SHR 1.8. These would occupy nearly 10% of the roof area and may have constructional, structural or environmental implications for the building. Furthermore office buildings tend to be designed with suspended ceiling heights of the order to 3 m. This imposes a limit on the DPF that can be achieved if the SHR of the output device is constrained by, say, a luminaire grid or structural requirements. If Building 22 were to be relit using a grid spacing of 1.25 for both lighting devices there would be about 100 unit of each. Using 300 mm diameter output devices the DPF would be 0.7%; for 500 mm diameter 1.6%; and for 650 mm diameter 2.8%. Under these circumstances the capital cost of a suitable TDGS is likely to be several times that of electric system and raises the question of whether the benefits of the daylight delivered by the system are sufficient to offset this.

4 CONCLUSION

The TDGS studied in this work with their dominant electric lighting and low daylight penetration represent a lost opportunity for their designers. Whilst it is clear that TDGS can provide daylight in deep open plan spaces, users appeared reluctant to regard it as such. The results suggest that TDGS, of whatever configuration, are considered inferior to windows in delivery of most aspects of quantity and quality of 'daylight' although satisfaction of some aspects improves with increased average DPF. There is a case for including windows – however small – in offices lit using TGDS to aid user interaction with the exterior.

It is pertinent to pose the question – what is the worth of the TDGS in offices as presently configured? Whilst it is clear that open plan offices with windows and TDGS perform better than those without windows there is not sufficient evidence as to whether deep plan offices with TDGS perform better than those without. More work is needed on this. The popularity of daylight is evident and user perception of this, and its benefits, seems to increase with increasing daylight penetration. This work offered no opportunity to establish if DPF of the order of 2% would produce a 'well daylight space' but it is clear that the practicalities of providing this using TDGS are not trivial. Before the question can be finally answered the benefits of using TDGS in terms of delivery of daylight and any energy savings need to be balanced against long term costs of such systems.

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COMPUTATION OF POWER LOSSES IN PUBLIC LIGHTING NETWORKS

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ABSTRACT

In our present society, public lighting has become a necessity. The modern public lighting networks include mostly high-pressure mercury and sodium lamps, operating based on the arc-discharging phenomenon. Due to the non-linear characteristic of the lamps and to the fact that the lamps are unequal distributed on the three phases of the 3 phase-4 wires lighting network, the latter is functioning in a unbalanced and non-sinusoidal regime.

The existence of this non-sinusoidal and unbalanced regime leads to many negative effects; from them, the growth of power losses in the phase conductors and the neutral conductor respectively, represents the interest issue of this paper. The assessment of power losses is very important in the stage of design and exploitation of the lighting networks.

Based on the mathematical relationships and theoretical results presented to the last editions of this conference [2, 3], the authors have created an original software tool that calculates the power losses in public lighting networks.

The paper presents this software tool by describing its working methodology and the mathematical relationships implemented to obtain power losses. The product is very friendly user and assists people with reduced computer knowledge during operation. An analysis of a real public lighting network from Cluj-Napoca is also presented.

1 INTRODUCTION

Public lighting has become an ordinary aspect of our modern society. Unfortunately, due to the existence of discharge lighting sources, present low voltage three-phase 4 wires public lighting networks have problems from both power quality and neutral current points of view; practically, they are working in a non-sinusoidal and unbalanced regime.

The effects of this operation state decrease the energy transfer efficiency as a consequence of additional power losses in lines and transformers. Considering the necessity of accurate knowledge of power losses in public lighting networks design and operation stages, a dedicated software tool was created. This tool calculates power losses in public lighting networks that operate in a non-sinusoidal and unbalanced regime.

Further on, the paper presents aspects about modern public lighting networks, the software tool interface, working methodology and analytic support; finally, the analysis of a real public lighting network is presented.

2 PUBLIC LIGHTING NETWORKS FUNCTIONING IN A NON-SINUSOIDAL AND UNBALANCED REGIME

Modern public lighting networks include discharge lamps, like high-pressure mercury/sodium lamps, which are single-phase non-linear loads. It is known that in the case of three phase four wire distribution networks containing non-linear loads, an important effect of the harmonic pollution consists of a supplementary neutral current. For balanced systems, the neutral current is the summation of the 3k order harmonic currents, that is:

$$i_n = 3\sum_{k=1}^{\infty} I_{3k} \cdot \sin(3 \cdot k \cdot \omega \cdot t + \beta_k) \qquad (1)$$

with the RMS value

$$I_n = 3\sqrt{\sum_{k-1}^{\infty} I_{3k}^2} \tag{2}$$

where I_{3k} is the RMS value of the 3k harmonic current.

In order to establish the non-sinusoidal state imposed by the discharge lamps, measurements have been performed using a FLUKE 43 Power Quality device. Common luminaries of different wattages equipped with high-pressure mercury/sodium lamps and ballast were studied.

The next figures illustrate the line current harmonic spectrum for the high intensity discharge lamps LPN250, LPN150 and LVF250, and the voltage and current waveforms for LPN150 respectively.

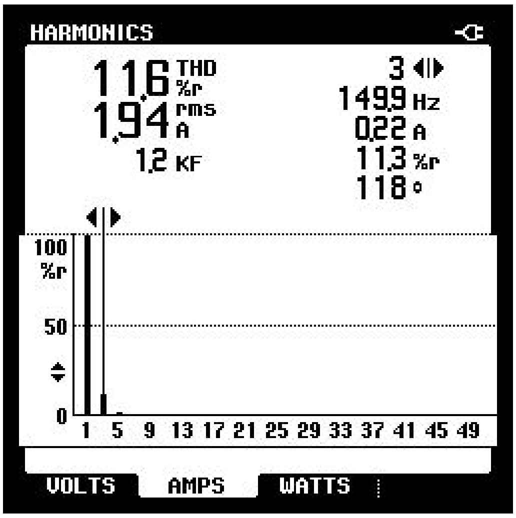

Figure 1 Harmonic current spectrum – LVF250

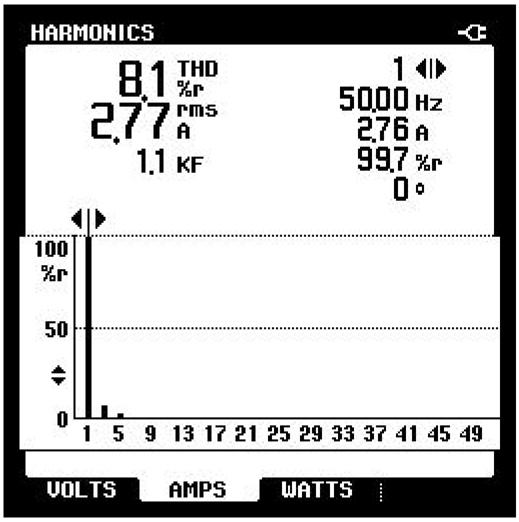

Figure 2 Harmonic current spectrum – LPN250

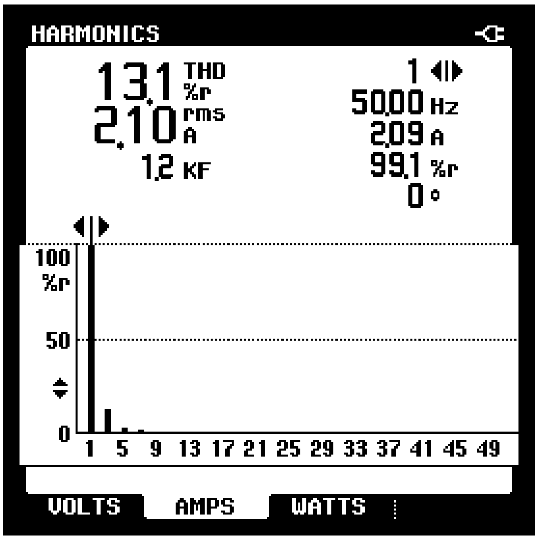

Figure 3 Harmonic current spectrum – LPN150

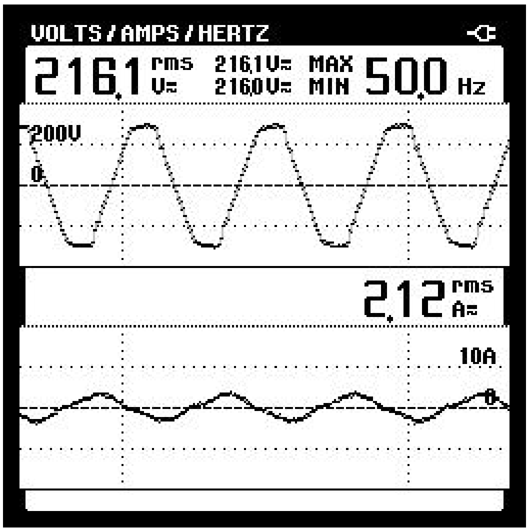

Figure 4 Voltage and current waveforms – LPN150

In most cases, in a public lighting network, lamps are unequally distributed between the three phases, and thus the electrical distribution system becomes unbalanced. In this situation, through each line conductor currents with different RMS values are flowing, and the neutral current is the summation of the 3k order harmonic currents plus the zero phase sequence of the 3k+1, 3k-1 harmonics, and fundamental current respectively.

2.1 Calculus of power losses

An alarming consequence of the non-sinusoidal unbalanced existing regime is the increase of power losses in the active conductors and especially neutral conductor.

Considering a public lighting network that illuminates a roadway, figure 5, power losses can be obtained by using the relationship (3).

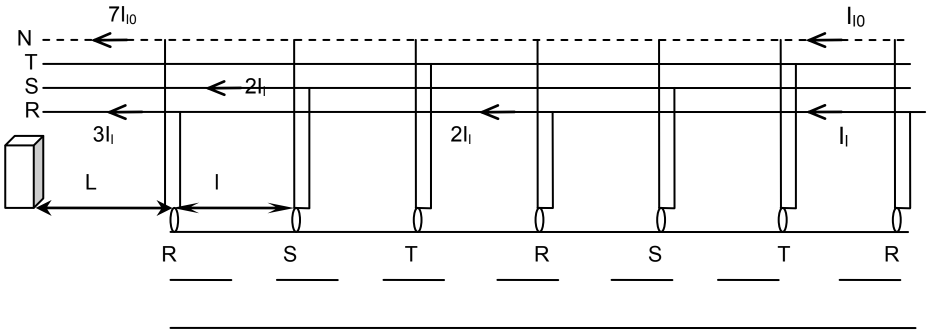

Figure 5 Public lighting network – electrical connection and currents flow

$$\Delta P_{Total} = \Delta P_R + \Delta P_S + \Delta P_T + \Delta P_N \ [W];$$
$$\Delta P_X = \sum r \cdot l_y \cdot \sum_{k-1}^{N} I_k^2 \ [W], \quad X = R, S, T, N; \qquad (3)$$

where ΔP_{Total} are total power losses;
ΔP_X – power losses in an active (neutral) conductor;
I_k – k order harmonic current;
r – conductor resistance per unit length;
l_y – segment length of the phase(neutral) conductor for which the power losses is calculated.

Additional power losses in the unbalance non-sinusoidal operation can be calculated by using relationship (4), where the total power losses are reported to the power losses calculated for a sinusoidal balanced operation.

$$\Delta p = \frac{\Delta P_{Total} - \Delta P_{\sin}}{\Delta P_{\sin}} \cdot 100 [\%] \qquad (4)$$

where Δp represents the additional power losses;
ΔP_{sin} - the power losses in sinusoidal balanced regime.

The calculus of $\Delta P_{\sin}$ is made considering the following aspects:
- the network supplies linear loads having the same total power as the real case;
- the distribution of the lamps between phases is made as presented in reference [1].

3 SOFTWARE TOOL

The software tool calculates active power losses in the electric conductors of a public lighting network, considering the unbalanced non-sinusoidal state caused by the discharge lamps. The informatics program is composed of two parts: a friendly GUI (graphic user interface) and the operating modules, further described on this chapter. For developing an easy to use software tool, the Borland C++ Builder visual development environment was used.

3.1 Graphic User Interface

The graphic user interface represents the part of the software with which the user comes in contact, so that a simple and easy to understand GUI was built up. Through it, user can introduce the input data and visualize the obtained results. GUI consists of one main window, presented in figure 6, and several auxiliary windows. The secondary windows were made for different purposes:

- to introduce supplementary input data;
- to show lamps database;
- to assist the user for different operations.

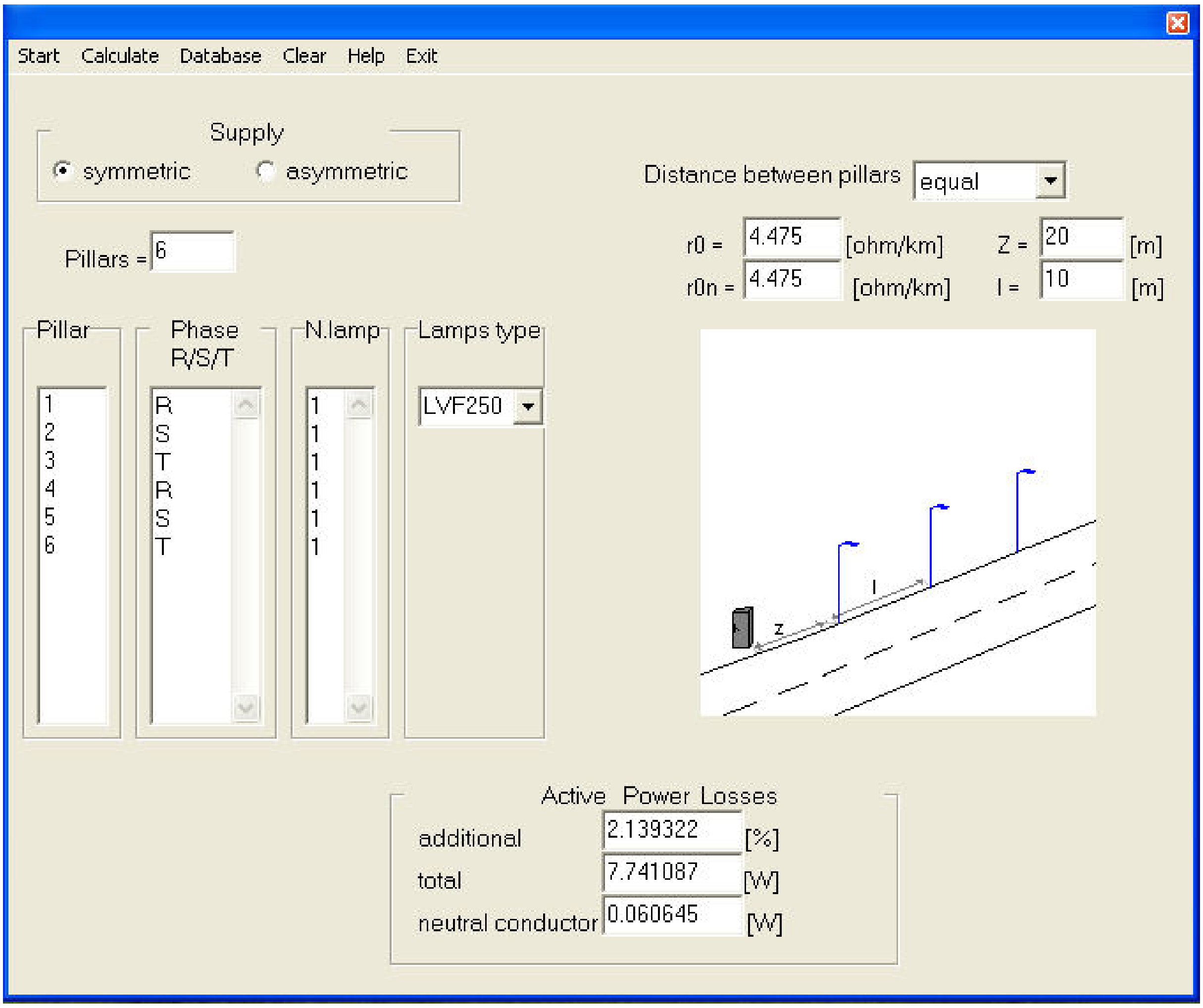

Figure 6 Graphic User Interface – main window

3.2 Operating modules

The operating modules represent the source code of the software written in C++ and user has not access to them. These modules have different functions:

- to add new lamps in the database;
- to adjust input data depending on the supply and on the type of the electrical public lighting network;
- to calculate power losses.

Considering the main issue of the present paper, the operating module that calculates power losses has the greatest importance, and as a consequence this module will be presented further on.

Figure 7 shows the working diagram of the power losses module; as it is described in this picture, the calculus begins by pressing “Calculate” field of the main menu bar. There are some steps that are performed:

- Input data are read;
- The phase coupling is verified;
- For each phase the following data are calculated:
    - the RMS value of the current,
    - the length of the conductor,
    - the active power losses;
- RMS value of the neutral current and corresponding power losses are calculated;
- Total power losses and additional power losses are determined;
- Results are put on desktop for visualization.

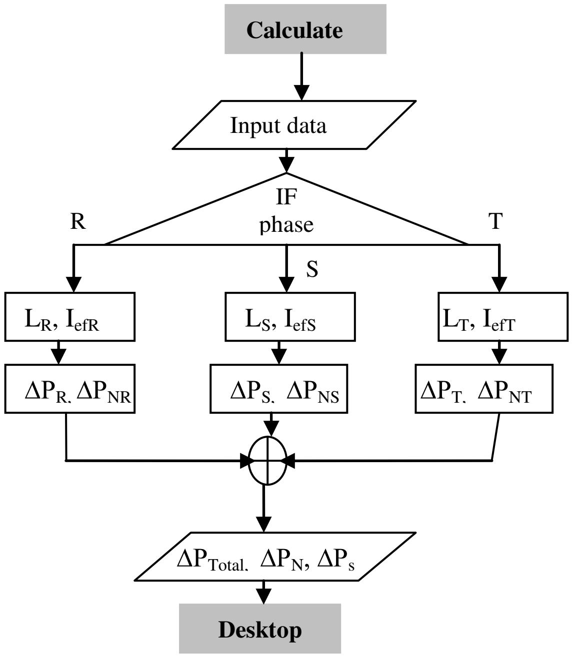

Figure 7 Working diagram of the PLM

4 ANALYSIS OF A REAL PUBLIC LIGHTING NETWORK IN CLUJ-NAPOCA

To test the created software tool, a real electrical public lighting network was studied. In the last years, during a campaign of modernization, a main task was to improve the photometric performances of public lighting systems; simultaneously, an other goal was to grow the efficiency of the electric network, in order to decrease the power consummation, i.e. voltage and energy losses. Accordingly, the existing luminaries PVB-7 B 1x250 W and PVO-1x250 W, have been replaced by new ones M2A – TC 150 W, more efficient. For supplying the luminaries, the following types of conductors were used:

- AFYI 3x35+35 mm^2 between pillars; r_0= *0,871 [Ω/km]*;
- ACYAbY 3x50+25 mm^2 from the plugboard to the first pillar; r_0= *1,116 [Ω/km].*

The analyzed public lighting network contains a number of 40 pillars and has the following characteristics:

- distance between the first pillar and the plug board *z = 20 m*;
- distance between the pillars *l = 30 m*;
- on every pillar there is a single luminary and each luminary has one lamp.

Harmonic spectrum of M2A – TC 150 W lamp is presented in Table 1.

Table 1 Currents harmonic spectrum of M2A – TC 150 lamp

Harmonic order k=1,N	1	3	5	7	9
RMS value of the harmonic current I_k [A]	1.82	0.27	0.06	0.04	0
Phase angle of the harmonic current φ_k [degrees]	0˚	132˚	115˚	152˚	-

Before the computation, the following characteristics were selected on the main window:

- the supply - “symmetric”;
- the distance between – “equal”;

After the calculus is made, the obtained results are presented in Table 2 where ΔP_{Total} [W] denotes total power losses, ΔP_s [%] - additional power losses, ΔP_{sin} [W] – ideal power losses (balanced loading and linear loads), and ΔP_N [W] – power losses in the neutral conductor.

Tabel 2 Results comparison

Lamp / Power losses	PVB-7 B 1x250 W	M2A – TC 150 W
ΔP_{Total} [W]	795.49	765.49
ΔP_{sin} [W]	658.41	579.47
ΔP_s [%]	20.82	28.08
ΔP_N [W]	75.51	125.21

5 CONCLUSIONS

Electrical public lighting networks practically operate in a non-sinusoidal unbalanced state that causes additional power losses in the active conductors and neutral conductor. As the knowledge of power losses has a great importance in the stage of design and exploitation of the lighting network, the necessity of power losses computation considering the real non-sinusoidal unbalanced existing regime became imperative. Considering these aspects, a software tool that calculates power losses in electric networks supplying public lighting luminaries was designed.

The proposed software was used to analyze a real electric public lighting network in Cluj-Napoca, where the existing PVB-7 B 1x250 W (high pressure mercury lamps) were replaced by new ones that consume less power: M2A – TC 150 W (high pressure sodium lamp). From the results, it can be seen that this process decreased the supplied power and the total power losses but produces an increase of the additional power losses. These results can be explained considering the harmonic spectrum of the lamps: the high-pressure sodium lamp introduces more harmonics than the high-pressure mercury lamp.

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OUTDOOR LIGHTING PROGRAM OF CHUNGJU CITY IN KOREA

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ABSTRACT

Chungju city with natural environment and diverse cultural heritages recently meets the top of tourism potential because of the opening of Jungbu Naeruk Expressway. Now, the outdoor lightings come to the major issues to improve Chungju city images and to exploit new scenic spots. This paper aims to introduce the status of Chungju night views and the outdoor lighting programs on launch. The current outdoor lighting programs has the objective in undertaking mainly for the parks, and express the traditional beauty and contemporary city as well as to provide the new resting spaces for citizens.

Keywords: Chungju city, Outdoor lighting, Night views, traditional aesthetics, contemporary images

1 INTRODUCTION

Chungju city, located in the central part of Korea, is encountered with the new era of advancement by the opening of Jungbu Naeruk Expressway, invitation of entrepreneur city, and others. In addition, with the rich water resource including several hot-springs, natural environment and diverse history with significant cultural heritages, the city is developing with its tourism potential. For this purpose, the city hosts various cultural festivals, including World Martial Art Competition, Ureuk Cultural Festival, Suanbo Hot Spring Festival, Chungju Apple Festival, Lake Festival and others in addition to its outdoor lighting programs for some buildings and sites, such as Gwanna Park, Culture Center and others. Therefore, this paper aims to introduce the current status of Chungju night views for the representative tourism resources and the new outdoor lighting plans on launch.

2 CURRENT STATUS OF CHUNGJU CITY

The tourism resources of Chungju city, integrated with Jungwon-gun in 1995, could be classified largely into the four territories as shown in (Figure 1). According to the guide book of Chungju city, there are 11 scenic points within the territory. The representative scenic points of Chungju city are shown as follow.

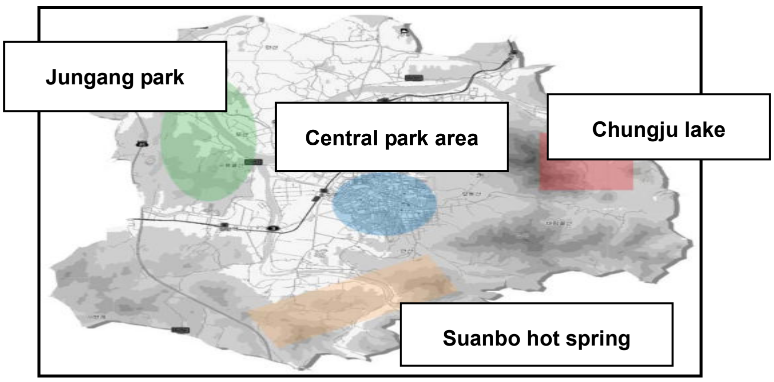

Figure 1 Four territories of Chungju city

2.1. Chungju Gymnasium Square

For the sport facilities in Chungju downtown, this building is equipped to host basketball, hand ball, and volley ball, boxing and other general sports event as well as diverse incidental facilities, such as table tennis class, aerobic class, physical training room and others. For each year, there are various cultural festivals, including Chungju World Martial Art Festival, Apple Festival, and others. However, it is a favorite space for Chungju citizen to enjoy, the activities at night are restricted because of insufficient lightings.

Figure 2 The day and night images of Chungju Gymnasium Square

2.2 Multipurpose Sports Facilities

This is the integrated sports facilities adjacent to Hoam Lake Park. The facilities are consisted of Taekgyeon Training Center, to preserve, disperse and advance our traditional martial art on Taekgeyon, the Sports Center and the Youth Training Center. The Youth Training Center was established for the purpose of providing healthy youth culture with the goal in developing the potential capability and harmonious personal nature. In addition, Hoam Sports Center with the badminton competition facilities has been undertaking the role to improve the physical fitness and cultural facilities for Chungju citizens.

Figure 3 The day and night images of Multipurpose Sports Facilities

2.3 Gwana Park

Figure 4 The day and night images of Gwana Park

This is the place to clean and set the government site of Chungjumok during the Joseon Dynasty, and had the Office of Jungwon-gun before, and the past Chungju District Court and District Prosecutor's Office are cleared and re-set the area and named it as Gwana Park. In the surrounding area, there are two 500-year old elm trees, and there are ancient buildings of Cheongnyeonheon (Local Cultural Property Number 66) that was used as government office in the past, and Jegeumdang (Local Cultural Property Number 67) to bring back the sentiment of old days.

2.4 Tangeundae and Central Park

Tangeumdae is a low hill with the elevation of around 100m and is the place for music master of Silla Dynasty, Ureuk (around AD 536) to teach his pupils with songs, Gayareum (a musical instrument) and dance. There are outdoor music hall and archery field. Adjacent to Namhangang River, it has the beautiful scenery with dense pine forest on the weird looking rocks on the cliff. Furthermore, Central Park near to Tangeumdae is a favorite waterside park for the Chungju citizens that have various water sports facilities, musical water fountain, Sculpture Park and Jungang Tower, built during Silla Dynasty.

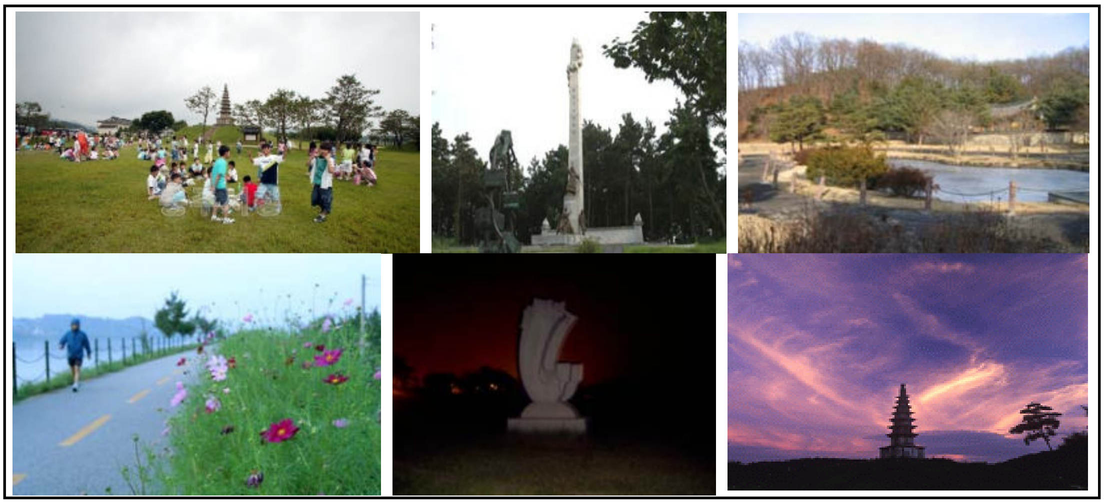

Figure 5 The day and night images of Tangeundae and Central Park

2.5 Hoam Lake Park

This is an artificial park with the circumference of approximately 4km located in the Chungju downtown, and it is liked to the multi-purpose sports facilities around that it is used as the sports and resting space of citizens and it is a favorite civic park where many citizens enjoy for boating and other activities on weekends. There are various cultural events, such as, Chungju Apple Festival, World Martial Art Festival, Chungju Culture Festival and others, and currently there are on-going scenic lighting plan.

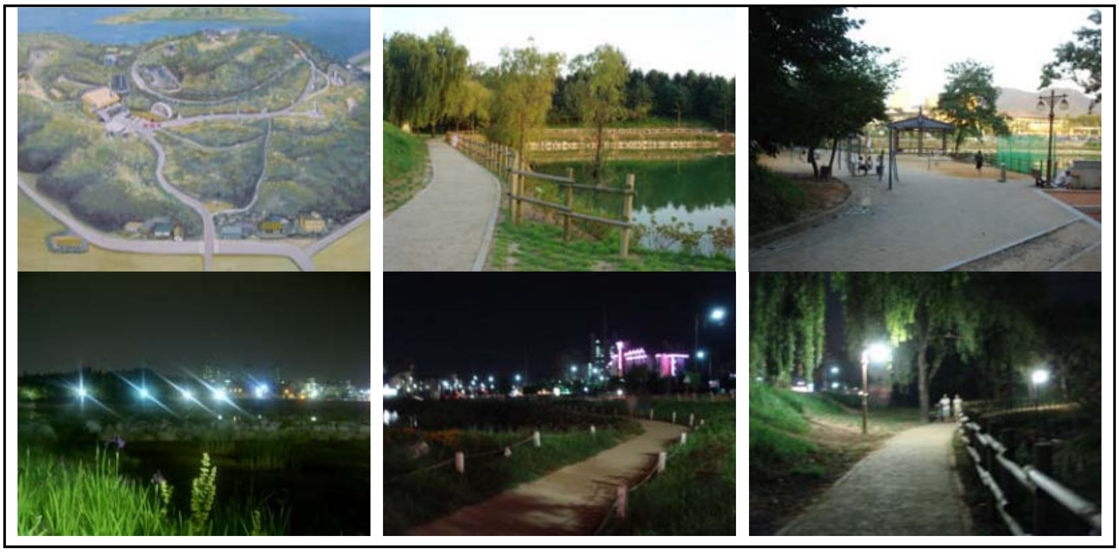

Figure 6 The day and night images of Hoam Lake Park

3 OUTDOOR LIGHTING PLANS IN CHUNGJU CITY

For the establishment of tourism city and the development of new resources, Chungju city plans for various outdoor lighting programs on the basis of the park facilities. The current lighting plans are shown as follow.

3.1 Central Tower in Central Park

Central Park has the lighting plan on the basis of the Central Tower and the Sculpture Park. The Central Tower has the cultural implication in symbolizing the center of Korea and historic implication of the tower as well as undertaking the role as the landmark. It lights on the upper part of the tower to feel the sense of elevation of the tower and improve the recognition from far distance away. The hiking path constructed along Namhan River provides the resting place to enjoy the surrounding views with the lighting on the trees and paths and it is connected with the space of the Outdoor Art Exhibition. For this purpose, the existing street light facilities are expanded and the outdoor sculpture works are installed with the lights to build up the culture space with many things to enjoy.

Figure 7 Central Townplan

Figure 8 Outdoor Lighting Plan and Musical Fountain of Central Park

3.2 Hoam Lake Park

Due to the lack of lighting facilities in the park that is as favorite site for Chungju citizens, it could be abstain from making use of the park at night. By lighting on the flower beds and rocks in the front of the park, it brightens and emphasizes the entrance of the park and hiking path. And then, the reflected lighting images on the lake are generated by lighting from the surrounding Multipurpose Sports

Facilities and trees. Overall, the plan is set to promote the level of the outdoor night scenes through lighting around the lake. In the event of hiking path, there is a underground lighting to emerge the rich leaves of trees. The sports area in the middle of the hiking path has the mercury street lightings replaced with the metal halide lamps to promote the night sports activities.

Figure 9 Outdoor Lighting Plan of Hoam Lake Park

3.3 Gwana Park and Gwana Gallery

The outdoor lighting of Changnyeonheon and Jegeumdang in Gwana park uses the current lighting fixtures on the traditional buildings to generate bright, magnificent and mysterious atmosphere to simultaneously express the traditional aesthetics and contemporary sophistication. The lighting plan uses the underground lightings to shed the light on the pillars and eaves of Changnyeonheon to emphasize the elegance of the eave lines. The park entry uses the luminance light to attract the visits of citizens and improve the recognition of the entrance. For this purpose, the underground lighting is used to light on the four pillars and eaves to display the splendor of the colorful painting and emphasize the eave lines. Also, the trees surrounding the entrance are lighted to provide the sufficient brightness and energetic atmosphere.

Figure 10 Outdoor Lighting Plan of Changnyeonheon, Jegeumdang and Entrance in Gwana Park

4 CONCLUSIONS

This paper has introduced the outdoor lighting plans and the new scenic resources to establish the status of Chungju city as the historic and cultural tourism city. The current outdoor lighting plans have the objective in undertaking mainly for the parks, and to express the images of Chungju city for its traditional beauty and contemporary city as well as to provide the new resting spaces for its citizens. In addition to the above plans, Chungju city, as the central city in the Korea peninsula, launches the comprehensive lighting plan that is linked to city and the nearby hot spring areas (Suanbo, Angseong, and Mungang) to develop the national resort to represent Korea.

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THE EUROPEAN GREENLIGHT PROGRAMME ENERGY EFFICIENT STREET LIGHTING

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ABSTRACT

To convince end-users to adopt efficient lighting technologies and systems and achieve a long lasting market transformation, the European Commission launched in 2000 the European GreenLight programme. It is an on-going voluntary programme whereby private and public organisations (referred to as Partners) commit to adopting energy-efficient lighting measures. GreenLight Partners report annually on their achievements within the programme. In return for their commitment, not only do they benefit from large savings, but they also receive broad public recognition for their effort in protecting the environment. So far, GreenLight has gathered more than 300 public and private organisations.

A new project supported by the Intelligent Energy for Europe Programme has been started at the beginning of 2006 to promote the GreenLight Programme in some of the new Member States and Candidate Countries.

For North Transylvania - Romania, the total street lighting electricity consumption is around 80,000 MWh/year. By convincing the local municipalities to become a GreenLight Partner, by installing new and efficient street lighting systems or upgrading the old ones, a great amount of energy and money could be saved.

1 INTRODUCTION

Lighting electricity use in the European non-residential sector represents more than 160 TWh/year. Major energy savings can be achieved. Examples from the field have shown that between 30% and 50% of electricity used for lighting could be saved investing in energy-efficient lighting technologies. In most cases, such investments are not only profitable but they also maintain or improve lighting quality. To pull the demand for efficient technologies, the European Commission (EC) launched in February 2000 the European GreenLight Programme. It is an on-going voluntary programme whereby private and public organisations (referred to as Partners) commit to adopting energy-efficient lighting measures when (1) the cost of these measures is repaid by the associated savings and (2) lighting quality is maintained or improved. In return for their commitment, not only do these Partners benefit from the savings, but they also receive broad public recognition for their effort in protecting the environment. The full details of the GreenLight Programme, are available on the web site at www.eu-greenlight.org.

In 2001, after nearly one year of operation, the EC reported that 18 organisations had joined the programme as Partners and that 28 companies in the lighting business had committed to acting as GreenLight Endorsers. Endorsers support Partners in their efforts to reduce lighting consumption. GreenLight was also said to have gained public support from national energy agencies and similar organisations (referred to as Promoters) in 26 European countries. A number of suggestions were also given to keep GreenLight growing (Berrutto and Bertoldi 2001). At the time of this writing, in March 2006, five years have elapsed since the first GreenLight progress report. More Partners and Endorsers have joined GreenLight. First savings estimates have been possible and public recognition has taken shape. These results are detailed in the present paper.

2 PROGRESS MONITORING

The GreenLight programme expects its Partners to report annually on their own achievements within the programme.

At the beginning of each year, Partners shall report their facilities that were upgraded, or newly built, according to the GreenLight Guidelines during the year before (yearly progress). The Partner shall also report their facilities for which upgrade is foreseen in the year to come (yearly mission statement).

Once filled, the reporting form shall be signed by the person of the company responsible for implementing GreenLight (so-called GreenLight Manager). The form shall then be sent to the European Commission Joint Research Centre (JRC). The JRC is responsible for monitoring GreenLight progress. The JRC also checks that reported savings are consistent with the baseline and post-installation lighting characteristics. It also controls that these latter characteristics are themselves consistent with realistic lighting practices. This cross-checking has proved to be useful to spot anomalies. It can be complemented by spot visits of lighting installation by GreenLight Promoters. Systematic verification by independent third parties of the information published in GreenLight reports is not foreseen. More comprehensive, longer reporting forms would obviously provide further ways to check the accuracy of the reported data. However, the first experience with a multi-page reporting form turned out to be unsatisfactory according to most Partners who found the form too demanding (JRC 2002). The form was subsequently reduced to a minimum to be acceptable by all users.

In an attempt to facilitate further the reporting process, the form was made available on the GreenLight web site in a fill-and-print format. This format provides automatic calculations and pulldown menus with list of possible technology choices. Also, the few Partners wishing to use their own in-house reporting format have so far been allowed to do so.

3 RESULTS

By March 2006, a total of 285 Partners signed the GreenLight partnership, thereby committing to adopting energy-efficient lighting practices in their premises. This represents more than a 14 fold increase compared to the first progress report (Berrutto and Bertoldi 2001), and during the last years of operation the number of Partners almost doubled. It confirms the observation made in the last report that the rate of registration was steadily increasing.

4 PARTNERS' REWARDS

During the last year, GreenLight public recognition has taken shape and the programme has gained public image. National Promoters had several articles published in the business press and technical magazines. The programme was presented in various fairs and conferences across Europe e.g. Pollutec in France, Valo 2001 in Finland, Light+Building in Germany, IEECB'04. Publicity was also carried out through direct mail, local information meetings and the internet.

A plaque was designed to allow Partners to show their responsible entrepreneurship to their clients. A new brochure was distributed to potential Partners with several GreenLight success stories inside, presented in a clear, simple, and vivid way. Indeed case studies have been found to be very useful to convince peer companies to join. The brochure is available in English, French, German and Italian and translations are foreseen in other languages. It was also distributed to various media and to the national Promoters for distribution within their respective country.

Figure 1 GreenLight Partners plaque

The Commission introduced a European award for particularly active and successful Partners and Endorsers. In the first year, 2002, that the award was established, the GreenLight partner award went to Johnson & Johnson.

Technical support to Partners has continued. The GreenLight web site has been continuously updated by the EC Joint Research Centre, with contributions from the Promoters. The number of GreenLight Endorsers has grown to 149. Endorsers are committed to offering technical support to registered Partners.

5 THE NEW IEE PROJECT

The goal of the New GreenLight project is to achieve at least 110 new partners committing to the GreenLight principles in the new EU member and EU candidate countries and over 20 GWh/year of savings at the end of the project. Each National Contact Point should also identify at least 3 endorsers every year.

These results will be achieved by the transfer of current GL know-how from the EU15 to the new member states and by a range of marketing activities. These include the production of guidelines for potential partners and supporters, printed brochure, a CD-rom and PPT presentation, updating of the programme's web-site, promotion leaflet, organisation of seminars and individual consultations, conference presentations, etc.

The main objective of the proposed action is to enlarge the geographical scope of the European GreenLight Programme, which is an explicit part of the Action Plan to Improve Energy Efficiency in the European Community.

In the short term the objective is to develop energy-efficient lighting in building area when these practices generate sufficient energy savings to represent profitable investments, and maintain or improve lighting quality.

In the long run, GreenLight is expected to contribute to significant positive environmental impact, but also to a more sustainable energy policy and enhanced security of supply, as well as to other benefits such as better working conditions and improved competitiveness. GreenLight can indeed help overcome some of the key market barriers associated with cost-effective investments in energy efficient lighting technologies and methods (not only) in the new EU member states.

Each GL National Contact Point (participant of this project) will undertake a series of efforts to have local companies signed up. An effort will also be made to identify appropriate Endorsers as well who will assist with identifying project partners.

In order to achieve this, a series of local seminars will be organised, combined with individual face-to face meetings with the top-managers. Participants will present the GL programme at two major international conferences or workshops; to the redaction of a biannual newsletter highlighting success stories, new Partners, etc.; through the constitution of small GreenLight press dossier (prepared together with the JRC).

Participants will also answer all the GreenLight-related questions in their country and offer individual assistance to the GL partners and endorsers. They will also undertake a quick survey of national studies on lighting energy use and potential savings.

6 ENERGY EFFICIENT STREET LIGHTING

Folowing the aims of the New GreenLight project, in the present paper we made a short presentation of the present situation in the public sector in North Transylvania and of a simple example for the calculation of the payback period for a specific new street lighting design.

In Romania, there are some few energy efficient national laws regarding the public lighting:

- Law 199/2000 – The efficient use of energy
- Government Law 63/1998 regarding the terms of reference of the local municipalities
- SR EN 13433 Roads and pedestrian area lighting

The total electricity consumption for public lighting in 2007 for the six counties in North Transylvania (Bihor, Bistrita-Nasaud, Cluj, Maramures, Satu-Mare, Salaj) is about 80,000 MWh/year. The lighting energy consumption for the counties in north Transylvania is presented in Table 1. The data was received from National Electricity Distribution Company in North Transylvania, FDFEE Electrica Transilvania Nord. Based on the past years electricity consumption for street lighting and on the electricity bills it was possible to make some estimations about the future electricity consumption.

Only by installing dimming devices for the half of the street lighting installations in North Transylvania area, electricity savings of about 23,900 MWh/year (1,775,000 euro/year) can be reached. This leads in consequence to a saving of approximately 11,950 Ton of CO_2 / year. This sum corresponds to the 2004 average electricity consumption per household of approximately 23,800 Romanian households.

For the year 2020 the estimated electricity consumption for public lighting is estimated to reach 88,911 kWh/year (Figure 2).

Table 1. Street lighting electricity consumption - FDFEE Electrica Transilvania Nord

Nr. Crt.	SDFEE	2004	2005	2006	2007	2008	2010	2015	2020
		.1.1.1 Street lighting electricity consumption							
		[MWh/year]	[MWh/year]	[MWh/year]	[MWh/year]	[MWh/year]	[MWh/year]	[MWh/year]	[MWh/year]
1	**Bihor**	22,242	22,453	22,677	23,086	23,131	23,377	24,512	25,817
2	**Bistrita-N**	5,060	5,095	5,126	5,175	5,227	5,279	5,491	5,732
3	**Cluj**	20,550	20,744	21,124	21,391	21,618	21,853	22,835	23,876
4	**Maramures**	12,566	12,649	12,767	12,876	12,997	13,127	13,782	14,471
5	**Satu-Mare**	11,195	11,288	11,400	11,510	11,625	11,742	12,221	12,809
6	**Salaj**	5,475	5,518	5,573	5,629	5,673	5,714	5,955	6,206
7	**Total**	**77,088**	**77,747**	**78,667**	**79,667**	**80,271**	**81,092**	**84,796**	**88,911**

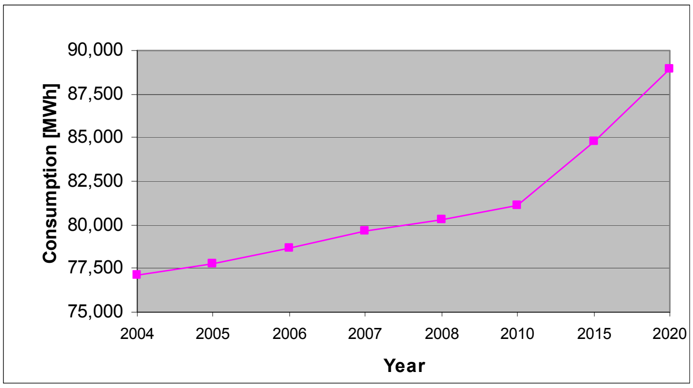

Figure 2 Evolution and prognosis of the street lighting electricity consumption - FDFEE Electrica Transilvania Nord

In Table 2 we can see the GreenLight calculation sheet for the cost-effectiveness of one (or two) energy-efficient lighting system(s) compared to one conventional street light installation. There were compared three street lighting systems: (1) so called conventional equipped with 250 W mercury lamps – light output 13,000 lm; (2) street lighting system equipped with 150 W sodium lamps – light output 14,500 lm; (3) street lighting system equipped with 150 W sodium lamps – light output 14,500 lm and dimming devices. The calculations were made for an outgoing project of Zalau's Municipality consisting of building a totally new residential area. A total number of 350 lamps was used for an adequate lighting of the 9.8 km of new streets. It was considered an average of 11 burning hours per day, which leads to a total number of 4015 operating hours per year. The average electricity price (0.074 euro/kWh) was calculated taking into consideration the general electricity tariff that FDFEE Electrica Transilvania Nord is using for the local municipalities (Tariff type: JE2: from 10.00 pm to 7.00 am – 0.111 euro/kWh and from 7.00 am to 10.00 pm – 0.066 euro/kWh). There were also some missing information, like "light source cost inflation rate", "disposal cost inflation rate" or "disposal cost per lamp" that will allow us to obtain even a shorter payback period. Because we have a new system, the cost for installing the street lighting system was not taken into consideration.

The same calculation was made comparing only two street lighting systems, both equipped with 150 W sodium lamps – light output 14,500 lm, only one using a control device able to dime the light output of the lamp. In this case the payback time is about 1.84 years (22.1 months), savings of about 71,668 kWh/year being achieved. This corresponds to a reduction of 5328 euro/year for the running costs of the system.

Table 2. Compared cost-effectiveness between conventional (mercury lamps), sodium lamps and sodium lamps plus dimming

Spreadsheet for assessing the cost-effectiveness of an energy-efficient lighting system(s) compared to conventional installation				
1. Project references				
Project name	**.1.2 Residential area - Zalau**			
Reference	Comp.	**HQL250**	**NAVT150Super**	**NAVT150Super+ZRM**
2. General data				
Average electricity price	Euro / kWh	0,07		
Electricity price inflation rate	%	2%		
Maintenance labour cost	Euro / hour	1,0		
Labour cost inflation rate	%	80%		
Light source cost inflation rate	%	0%		
Disposal cost inflation rate	%	0%		
Discount rate	%	4%		
System lifetime	Year	5		
Time to replace one lamp:				
in the case of spot maintenance	Minute	60		
in the case of group maintenance	Minute	60		
Time to clean one luminaire	Minute	60		

3. Lighting systems' characteristics				
Type of lighting system		**Conv.**	**Eff. 1**	**Eff. 2**
Lamp				
Rated wattage of one lamp	Watt	250	150	150
Rated lifetime	Hour	8000	20000	20000
Unit price	Euro / unit	5,50	14,00	14,00
Connecting device				
Power losses per connecting device	Watt	16	20	20
Unit price	Euro / unit			0,00
Luminaire assembly				
Number of lamps per luminaire		1	1	1
Number of connecting device per luminaire		1	1	1
Unit price of luminaire without lamp	Euro / unit	0	0	0
Unit price of luminaire with lamp(s) inside	Euro / unit	6	14	14
Power per luminaire (w/ lamps inside)	Watt	266	170	170
Control system				
Estimated energy savings	%	0%	0%	30%
Unit price	Euro	0	0	28
Lighting system				
Number of luminaires		350	350	350
Number of control systems		0	0	350
Total wattage of lighting system	Watt	93100	59500	59500
Other equipment cost	Euro	0	0	0
Cost of equipment	**Euro**	**1925**	**4900**	**14700**
4. Installation				
Cost for installing the lighting system	Euro			
Cost of installation	**Euro**	**0**	**0**	**0**
INITIAL COST	**Euro**	**1925**	**4900**	**14700**
5. Operation				
Energy use				
Daily burning time (average)	Hour	11	11	11
Number of operating days per year		365	365	365
Yearly operating hours	Hour	4015	4015	4015
Yearly energy consumption	kWh / year	373797	238893	167225
Yearly energy cost	**Euro**	**27788**	**17759**	**12431**
Lamp replacement				
Type of lamp replacement		spot	spot	spot
Number of minutes to replace one lamp	Minute	60	60	60
Disposal cost per lamp	Euro	0	0	0
Number of times one lamp is replaced during system's lifetime		2	1	1
Yearly cost for purchasing new lamps	Euro	770	980	980
Yearly cost for disposing old lamps	Euro	0	0	0
Yearly cost for installing new lamps	Euro	140	70	70
Yearly cost for lamp replacement	**Euro**	**910**	**1050**	**1050**
Luminaire cleaning				
Time laps between two cleaning	Year	N/A	N/A	N/A
Number of times one luminaire is cleaned		0	0	0
Yearly cost for luminaire cleaning	**Euro**	**0**	**0**	**0**
Yearly maintenance cost	**Euro**	**910**	**1050**	**1050**
YEARLY RUNNING COST	**Euro**	**28698**	**18809**	**13481**

6. Profitability				
Type of comparison			**Eff. 1 vs. Conv.**	**Eff. 2 vs. Conv.**
Payback Time	Year		**0,30**	**0,84**
Savings per year	kWh / year		**134904**	**206572**
	Euro / year		**10029**	**15357**
	Ton of CO2 / year		**67,5**	**103,3**

7 CONCLUSION

GreenLight is one of many new initiatives trying to create effective public private partnership to achieve societal and environmental benefits. GreenLight has proved to help its Partners save money and reduce pollution by increasing the energy efficiency of their lighting. GreenLight is changing the way organisations make decisions about energy-efficiency, elevating decision-making to senior corporate officials. Major players have joined the movement and several upgrades have got off the ground and flourished. These positive results prompted most national energy agencies to catalyse and spread further the programme implementation.

The main focus will in the New Members States and Candidate Countries, where there are currently no Partners, except one in Slovenia. In tangible terms, by end of 2006, the objectives are to increase and maintain a reporting rate of at least 80%, to pass the bar of four hundred registered Partners, and to double the current annual energy savings.

Great electricity savings can be achieved by using energy efficient street lighting systems. The Romanian municipalities, owners of the public lighting, should be aware about the great energy savings and running cost reduction potential of using modern energy efficient street lighting systems.
In order to achieve an energy efficient street lighting, integrate planning should be taken into consideration. The producers, the designers and the users of those modern systems should work together for achieving the most cost-efficient lighting solution.

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MANAGEMENT OF INDOOR LIGHTING SYSTEMS USING FUZZY CONTROLLERS

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ABSTRACT

Nowadays requirements regarding the sustainable development impose the diminution of energy consumption in indoor lighting systems. Daylighting is sometimes used for this purpose, because it will provide energy savings primarily through reductions in the operation of electric lighting. Under suitable conditions, daylight can reduce electric energy costs significantly; this is particularly important during peak power demand hours when the cost of electric energy may be much higher than during off-peak hours.

Paper presents a management system based on a fuzzy controller aiming to reduce power consumption on indoor lighting systems by using daylighting; the system uses three sensing devices (an occupancy/motion sensor and two photosensors), electronic dimming ballasts for every luminaries and a fuzzy controller. Taking into account the random pattern of potentially available daylight and rapid change of its characteristics, fuzzy control has proved to be a better solution than the traditional PID controllers.

Operation simulation realized by DIAlux has indicated appropriate values of illuminance levels and a good uniformity, proving the correctness of the proposed solution.

Keywords: artificial lighting, energy management, daylight, control strategies, fuzzy logic, fuzzy controller

1 INTRODUCTION

The era of electric lighting began a little more than a century ago with the invention of the incandescent lamp. Prior to that time, daylight was the principal illuminant in commercial buildings, with flame sources occasionally used to allow for earlier starting times or somewhat longer operations late in the day after daylight had faded. [1]

Electric lighting has proved to be a high-technology industry, with manufacturers devoting effort to research and development. Consequently, in recent decades, a succession of new, more efficient light sources, auxiliary equipment, and luminaries have been introduced. Research in basic seeing factors has also been pursued for many years, and a succession of developments has provided greater knowledge of many of the fundamental aspects of the quality and quantity of lighting. Some of these developments make it possible to provide for visual task performance using considerably less lighting energy than in the past. [1]

Owner objectives for lighting may vary over a broad scale depending on whether fast and accurate visual performance in a business-like environment is desired or whether the creation of mood and atmosphere in a space is of paramount importance. Lighting has great flexibility in this regard, and designers can vary its distribution and color, use its effect on room surfaces and objects to achieve dramatic, sparkling, somber, relaxing, or attention getting effects, as desired.

Nowadays requirements regarding the sustainable development impose the diminution of energy consumption and, consequently the implementation of energy management systems. Lighting controls, addressing controls for electric lighting, offer desired illuminance at appropriate times while reducing energy use and operating costs of lighting system. Studies of buildings that have implemented control strategies have shown that it is possible to reduce overall lighting energy consumption by as much as 70% in some areas.

Daylighting is sometimes used as an energy conservation measure, because it will provide energy savings primarily through reductions in the operation of electric lighting. Daylight can increase occupant satisfaction and conserve energy if considerations such as view design, glare control, human factors and integration of building systems are properly addressed. Although the daily and seasonal movements of the sun with respect to a particular geographic location produce a predictable pattern of amount and direction of potentially available daylight, a random pattern caused by changes in the weather, temperature and air pollution also coexists. When the sky is not completely overcast, the sky luminance distribution may change rapidly and by large amounts as the sun is alternately obscured, partly obscured or fully revealed.

In recent years, the control technology has been well developed and has become one of the most successful tools in the industry. However, traditional control systems, based on mathematical models, and often implemented as “proportional-integral-derivative (PID)” controllers, have shown their limits as daylighting energy-management controls for indoor lighting systems. Taking into account the random pattern of potentially available daylight and rapid change of it characteristics, fuzzy control has proved to be a better solution.

The paper presents a fuzzy controller for the management of indoor lighting systems using daylight. The structure of the controller, its operation rules and the influence ob the imposed value of the illuminance level are also analyzed.

2 INDOOR LIGHTING SYSTEMS

Nowadays, the fluorescent lamp is the primary light source for indoor applications. Unlike the incandescent lamp, which is a purely resistive load, the fluorescent lamp is a complex negative-resistance load requiring a ballast to maintain the proper electrical input for both starting and operation.

Uniform illuminances are often provided throughout a space. By definition, uniform lighting illuminates spaces and areas on and around the immediate work or task area equally. The use of uniform lighting has been criticized because of the potential for wasted energy from lighting in both task and non-task areas uniformly. Uniform lighting is frequently applied to areas in which the task or the task areas are not precisely defined; typical of these is 500 to 700 lux uniformly applied to speculative office space.

The principal applications for uniform lighting is in areas where the activity taking place occurs uniformly and continuously throughout the entire space and where task locations are quite close together, such as in classrooms or densely occupied office space. It should not be installed as a substitute for proper planning when it is not really required. Fixtures may be kept on site but not installed until the specific locations of workstations are known. An alternative approach, considering the 50 - 60 year life-cycle of a building during which time tasks may be performed anywhere in the space, is to install luminaries capable of supplying uniform illumination, but with switching controls that would allow a non-uniform lighting result in the space. With a task-tuning control strategy, the lighting system can be adjusted, or tuned, to provide local illumination as needed; considerable savings are possible through task tuning. This strategy results in the efficient use of energy for lighting without sacrificing occupant visual performance.

Typical spaces where uniform illuminance can be used to best advantage include:

- Densely occupied office space;
- Data processing centers;
- Classrooms;
- Gymnasiums;
- Mass merchandising stores;
- Sports fields.

In order to promote energy efficiency in uniform lighting installations, consideration should be given to multiple-level switching that uses two-level ballasts, switching one of a pair of ballasts in luminaries, switching of small areas of luminaries, and switching to lower lighting levels near windows, which can be utilized as a light source during daylight hours.

Coefficients of utilization values that are published by luminaries’ manufacturers are used to calculate average illumination levels for uniform lighting. Actual illumination values in a real space will be higher than average in the center of the space and lower near the edges of it. In small rooms, illumination may be 30% higher than average in the center, varying to near average in very large rooms. Consequently, uniform illumination can be reduced if tasks are located near the center of small and medium-sized rooms. Conversely, work locations near walls should be avoided unless task lighting is provided.

3 DAYLIGHT AND ELECTRIC LIGHTING

Today, energy conservation, cost, and availability, both present and future, should guide decisions on every energy subsystems of a building. Despite the dramatic reduction in the energy required to produce effective illumination, lighting continues to account for 40% of commercial building energy use. [1]

Daylighting is sometimes used as an energy conservation measure, because it will provide energy savings primarily through reductions in the operation of electric lighting. Under suitable conditions, daylight can reduce electric energy costs significantly; this is particularly important during peak power demand hours when the cost of electric energy may be much higher than during off-peak hours. Daylight can increase occupant satisfaction and conserve energy if considerations such as view design, glare control, human factors and integration of building systems are properly addressed.

There are at least two dimensions to daylight-responsive controls: the control of the daylight input to the space, and the control of the electric lighting output. The first is critical for providing adequate quantity and quality of daylight in interior spaces. The second saves energy and improves the overall distribution of light when daylight is insufficient. For both of these systems, user satisfaction and acceptance are extremely important. Annoyances caused by the system, such as glare, temporary reductions or sudden changes in brightness, or irritating mechanical noise, will reduce the system's effectiveness. However, maintaining a constant illumination level or luminance at some reference plane or point in a room by means of controls is not always desirable and is often impossible.

The main problem is that the skylight varies continuously and this variation represents one of the fundamental differences between day lighting and electric lighting design. The sky luminance and resultant illuminances vary with latitude, time of day, and the seasons; random variations in sky luminance also result from the density and movement of clouds. It is essential that the continuous time variation of daylight be considered in design as no single static condition can provide a reasonable basis for assessing a daylight design.

In side lit rooms, the illuminance at points near windows is rarely more than one-tenth of that outdoors and is often considerably less at points far from the window; a rule of thumb is that the distance of useful daylight penetration with side lighting is usually not more than twice the window head height. Room furnishings in particular may drastically reduce daylight penetration in side lit spaces. Nevertheless, the daylight in an interior space is of sufficient magnitude to be a useful contribution to the lighting of building interiors for much of the year. The introduction of target illuminance or luminance levels and variability about those targets is therefore a practical solution to the lighting of building interiors.

4 FUZZY CONTROL FOR THE MANAGEMENT OF AN INDOOR ELECTRIC LIGHTING SYSTEM

Energy-management controls for lighting systems provide energy and cost savings through reduced illuminance or reduced time of use. On the other side, energy management control strategies may significantly improve the esthetic quality of a space, and controls installed for esthetic purposes may produce significant energy savings. In the perimeter areas of buildings, part of the desired illumination can often be supplied by daylight. In these areas, reducing the electric lighting in proportion to the amount of available daylight will reduce energy consumption.

In recent years, the control technology has been well developed and has become one of the most successful tools in the industry. However, traditional control systems, based on mathematical models, and often implemented as “proportional-integral-derivative (PID)” controllers, have shown their limits as daylighting energy-management controls for indoor lighting systems. Taking into account the random pattern of potentially available daylight and rapid change of its characteristics, fuzzy control has proved to be a better solution.

4.1 Fuzzy control

Fuzzy logic is a computational paradigm originally developed in the early 1960's and represents a natural, continuous logic patterned after the approximate reasoning of human beings. Its use for solving control problems has tremendously increased over the last few years as fuzzy control has been demonstrated to provide highly satisfactory results in terms of accuracy, repeatability and insensivity to changes in operating conditions. Fuzzy control provides a formal methodology for representing, manipulating, and implementing a human's heuristic knowledge about how to control a system.

Fuzzy control and conventional control have similarities and differences. They are similar in the sense that they must address the same issues that are common to any control problem, such as stability and performance. However, there is a fundamental difference between fuzzy control and conventional control. Conventional control starts with a mathematical model of the process and controllers are designed based on the model. Fuzzy control, on the other hand, starts with heuristics and human expertise (in terms of fuzzy *IF-THEN* rules) and controllers are designed by synthesizing these rules.

For many practical problems, the mathematical model of the control process may not exist, or may be too "expensive" in terms of computer processing power and memory, but there are human experts who can provide heuristics and rule-of-thumb that are very useful for controlling the process. For these kinds of problems, a system based on empirical rules may be more effective and, consequently, the fuzzy control is most useful. If the mathematical model of the process is unknown, we can design fuzzy controllers in a systematic manner that guarantees certain key performance criteria.

4.2 Fuzzy controller

Fuzzy controllers are very simple conceptually. They consist of an input stage, a processing stage, and an output stage. The input stage maps sensors or other inputs, such as switches, thumbwheels, and so on, to the appropriate memberships functions and truth values. The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value.

The internal structure of a fuzzy controller is presented in Figure 1 and contains the following four basic components:

- Fuzzification unit: converts the crisp input variables into fuzzy ones so that they are compatible with the fuzzy set representation of the process state required by the inference unit.
- Knowledge base, consisting on two parts: a rule base that describes the control actions and a database that contains the definition of the fuzzy sets representing the linguistic terms used in the rules.
- Inference unit: generates fuzzy control actions applying the rules in the knowledge base to the current process state.
- Defuzzification unit: converts the fuzzy control action generated by the inference unit into a crisp value that can be used to drive the actuators.

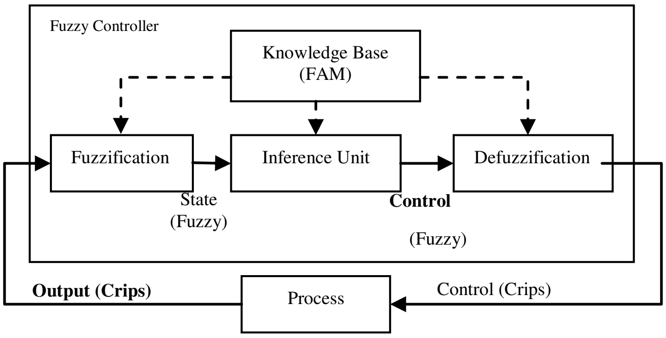

Figure 1 Basic structure of fuzzy logic controller

4.3 Management system based on a fuzzy controller

One major advantage of a lighting control system is that the illuminance can be automatically adjusted to suit the activity or tasks at hand. All lighting control systems contain three major components: (1) a power controller, (2) a logic circuit and (3) a sensing device. The controller, such as a dimmer, relay or switch electrically changes the output of the light source; the logic circuit is the intelligence that decides when, and how much, electric lighting to supply; the sensing device, such as a photosensor, an occupancy/motion sensor or a timing device provide the necessary information to the logic circuit.

A management system based on a fuzzy controller has as main advantage its capability to adapt to different control strategies (energy management, lumen maintenance, task tuning and esthetic control strategies) and to continuous variation of the skylight. The proposed indoor lighting management system uses three sensing devices (an occupancy/motion sensor and two photosensors), electronic dimming ballasts for every luminaries and a fuzzy controller; Figure 2 presents the control algorithm.

Controlling the light output via low-level signals – Figure 3 - allows electronic dimming ballast systems to be more flexible than magnetic ballast systems based on conditioning the ballast input power. Scheduling and lumen maintenance can be readily accomplished with electronic dimming ballast systems, since the ballast is controlled independently of the distribution system.

For the use of daylight, the subdivision of the building into sufficiently small control zones is an important consideration; large zones may not adequately respond to different lighting conditions within them. Figure 4 presents the layout of the studied lighting system: photosensors *CF1* and *CF2* will detect changes in the local level of the illuminance and send signals to the fuzzy controller to increase or decrease the luminous flux provided by the luminaries. In response to the signal, the electric lighting system may be adjusted by continuous dimming. The use of photosensors to control interior lighting is not trivial: proper design, placement and calibration of them are critical.

Until *a human body is present*
    if *illuminance is between 500 and 550 lux*
        then *hold constant all lamp parameters*
        else *use the fuzzy controller for lighting control*
after 5 min turn off all lamp.

Figure 2 Algorithm for indoor lighting control

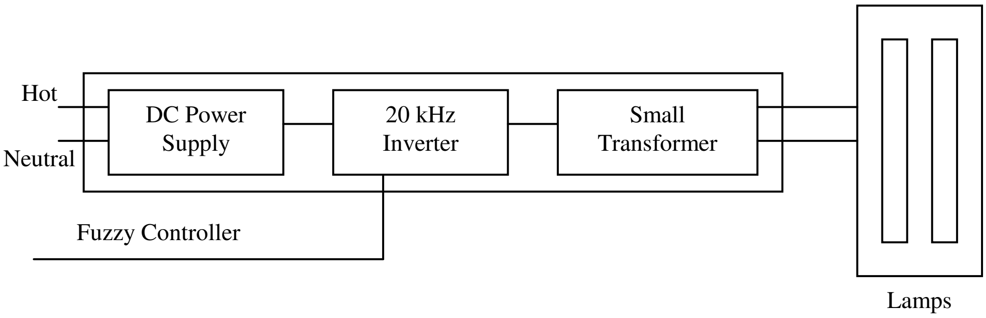

Figure 3 Fuzzy controlled electronic dimming ballast

Fuzzyfication

The input linguistic variables of the fuzzy controller are the level of the luminance measured by the two photosensors while the output variables are the luminaries' luminous intensity (which is proportionally with voltage supply). Every linguistic variable has five fuzzy values with triangular or trapezoid membership functions:

- For input variables – Figure 5: D – dark; H-D – half dark; H – half; H-L – half light; L – light;

For output variables – Figure 6: F-L – full lighting; SH-L – semi half lighting; H-L – half lighting; SS-L – semi stop lighting; S-L – stop lighting.

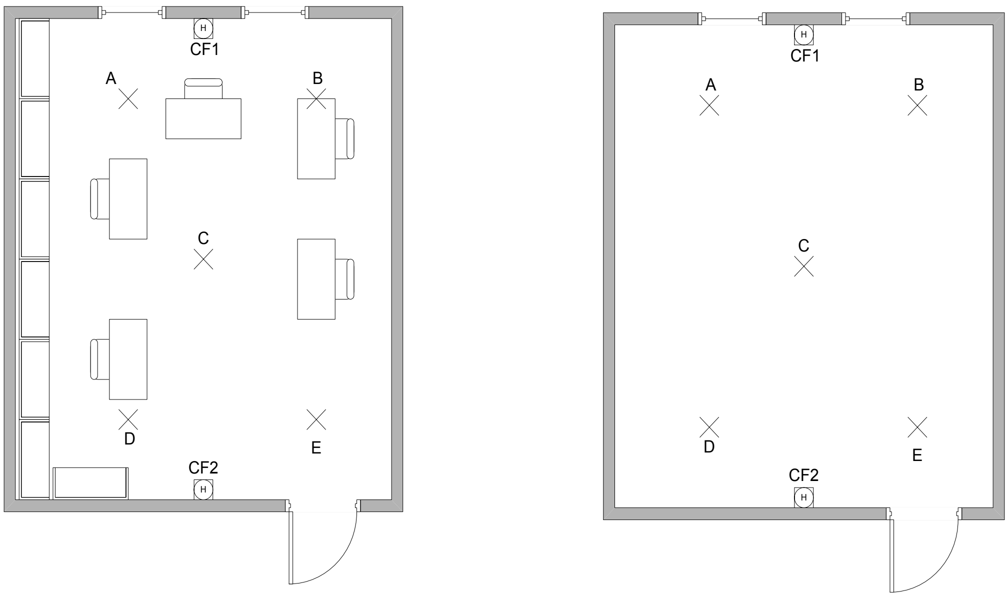

Figure 4 Layout of the studied indoor lighting system

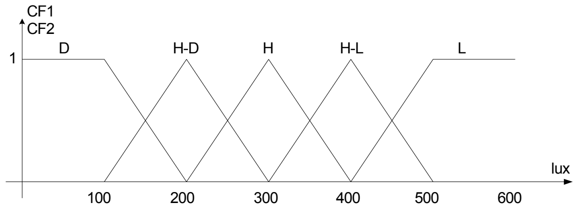

Figure 5 Input variables fuzzyfication

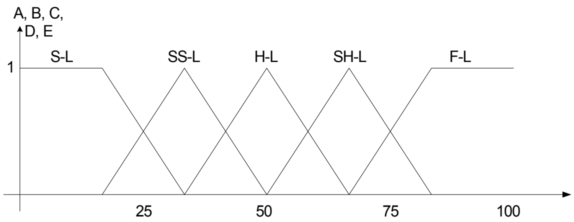

Figure 6 Output variables fuzzyfication

Knowledge base

The knowledge base used by the control system is presented in the Table 1 where α represents the fuzzy controller output variable.

Table 1

α_A, α_B,		CF1				
		D	H-D	H	H-L	L
CF2	D	F-L	F-L	SH-L	H-L	H-L
	H-D	F-L	F-L	SH-L	H-L	SS-L
	H	F-L	F-L	SH-L	H-L	SS-L
	H-L	F-L	F-L	SH-L	H-L	SS-L
	L	F-L	F-L	SH-L	H-L	SS-L

α_C		CF1				
		D	H-D	H	H-L	L
CF2	D	F-L	F-L	F-L	SH-L	SH-L
	H-D	F-L	F-L	SH-L	SH-L	H-L
	H	F-L	SH-L	SH-L	SH-L	H-L
	H-L	SH-L	SH-L	SH-L	H-L	H-L
	L	SH-L	SH-L	H-L	H-L	SS-L

α_D, α_E,		CF1				
		D	H-D	H	H-L	L
CF2	D	F-L	F-L	F-L	F-L	F-L
	H-D	SH-L	SH-L	SH-L	SH-L	SH-L
	H	H-L	H-L	H-L	H-L	H-L
	H-L	SS-L	SS-L	SS-L	SS-L	SS-L
	L	S-L	S-L	S-L	S-L	S-L

The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules; this mechanism was implemented by the max-min inference method.

Defuzzyfication

The results of all the rules that have fired are defuzzified to a crisp value by the centroid method and gives the crisp values of voltage supply for all five luminaries – Figure 7 for luminaries A and B, Figure 8 for the luminary C and Figure 9 for D and E luminaires.

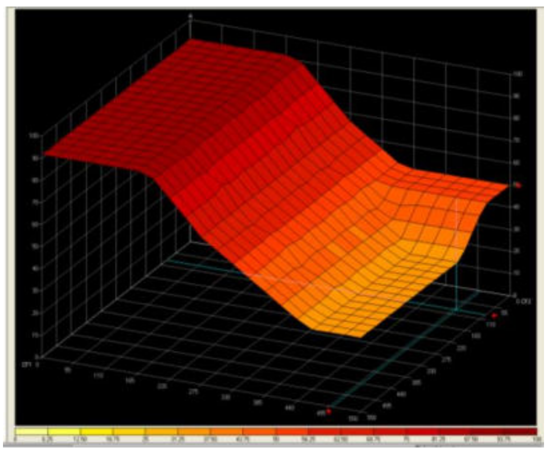

Figure 7 Percent variation of luminous flux in luminaries A and B

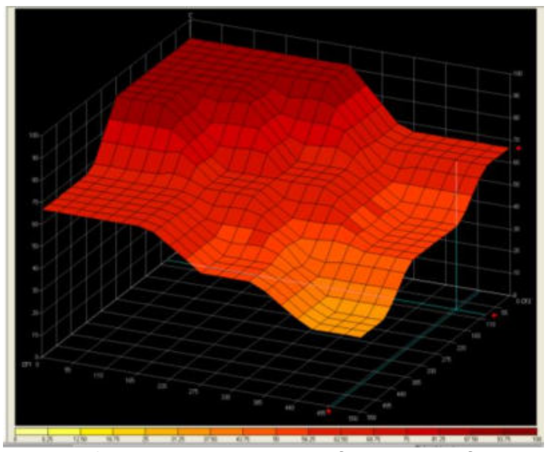

Figure 8 Percent variation of luminous flux in luminary C

5 SIMULATED RESULTS

The operation of the proposed fuzzy control system was simulated by the dedicated Dialux software package. Figure 10 presents the illuminance distribution levels of the artificial lighting system without the contribution of daylight.

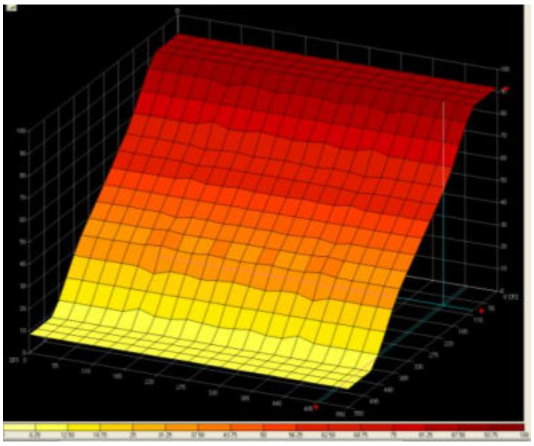

Figure 9 Percent variation of luminous flux in luminaries D and E

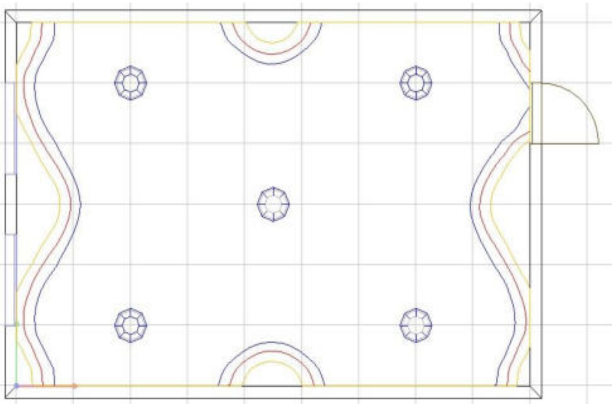

Figure 10 Illuminance produced by the uncontrolled electric lighting system:
a) blue – 550 lx; b) red – 500 lx;
c) yellow – 450 lx

Figures 11 and 12 present the distribution of illuminance levels in the presence of daylighting. The two photosensors indicate CF_1=600 lux; CF_2=120 lux, and CF_1=600 lux; CF_2=50 lux, respectively. As expected, the illuminance uniformity and level are very good on the sidelit part of the room and acceptable on the opposite side.

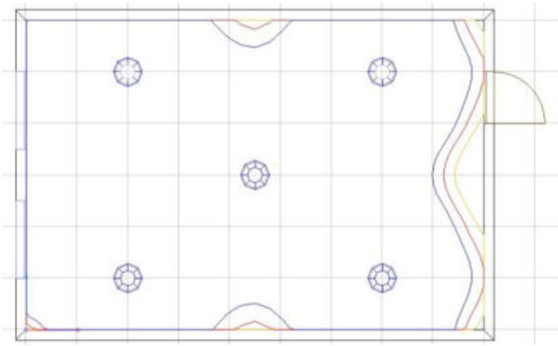

Figure 11 Influence of daylithing and fuzzy control for CF_1=600 lux; CF_2=120 lux
a) blue – 550 lx; b) red – 500 lx;
c) yellow – 450 lx

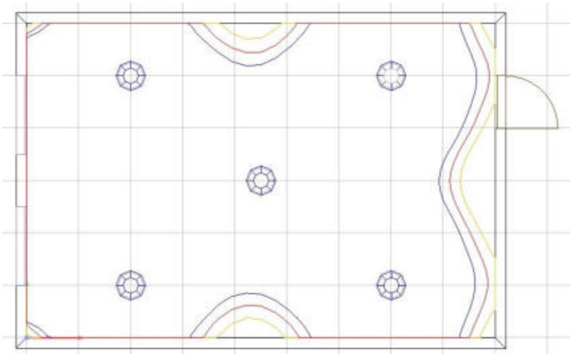

Figure 12 Influence of daylithing and fuzzy control for CF_1=600 lux; CF_2=50 lux
a) blue – 550 lx; b) red – 500 lx;
c) yellow – 450 lx

6 CONCLUSIONS

Nowadays requirements regarding the sustainable development impose the diminution of energy consumption and, consequently the implementation of energy management systems. Energy-management controls, addressing controls for electric lighting, offer desired illuminance at appropriate times while reducing energy use and operating costs of lighting system.

Daylighting is a convenient energy conservation measure, because it will provide energy savings primarily through reductions in the operation of electric lighting. However, traditional control systems, based on mathematical models, have shown their limits as daylighting energy-management controls for indoor lighting systems. Taking into account the random pattern of potentially available daylight and rapid change of its characteristics, fuzzy control has proved to be a better solution.

The proposed indoor lighting management system uses three sensing devices (an occupancy/motion sensor and two photosensors), electronic dimming ballasts for every luminaries and a fuzzy controller; the input variables of the controller are the illuminance levels measured by the two photosensors while the output variables are related to luminous fluxes provided by every luminary. Operation simulation realized by Dialux has indicated appropriate values of illuminance levels and a good uniformity, proving the correctness of the proposed solution.

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CONSIDERATIONS REGARDING FLICKER LEVEL OF INTERIOR FLUORESCENT LIGHTING SYSTEM

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ABSTRACT

The authors propose an analysis of the calculus opportunity of the illumination flicker level for the fluorescent lighting systems, previously performed to the interior supply network dimensioning of the lighting receivers, by starting from the physical and mathematical equations mentioned in literature [2] for this phenomena evaluation.

So that, there is considered the lighting installation of an industrial hall. For this one a photometric calculus was performed by using the method of utilization factor. For a chosen spatial distribution of the lighting sources there was determined the value of the direct illumination produced in different points of the work surface (useful plane), in horizontal plan (i.e. symmetry center of the surface) [1, 3].

The following cases were analyzed from the resulted flicker level point of view, as well as from that of its limitations by comparison with the case of one lamp:

1. *the case of three adjoining units mounted on the three power supply phases;*
2. *the case of two adjoining units, mounted on two phases or in duo-assembly with a φ current lagging;*
3. *the case of the ceiling formed by parallel rows of lighting units alternatively connected to the three supply network phases;*
4. *the case of parallel rows of lighting units with lamps in duo-assembly alternatively connected on the three supply network phases.*

1 INTRODUCTION

The flicker of luminous flux and consequently, the stroboscopic effect of the fluorescent lighting sources mean a continuous concern in order to get their mitigation, as well as to take fully advantages of these modern sources' types.

One of the most important issue to be considered when a fluorescent lighting system is developed should be the decreasing of the flicker of luminous flux (so that of illumination). The flicker generates that "stroboscopic effect", harmful for industry, where can leads to accidents, but also for public and civil spaces, where it appear as a very disturbing phenomena.

Therefore anti-stroboscopic assemblies are used to achieve the lagging of luminous fluxes produced by different sources that are lightening the same surface element. This lagging can be achieved either by mounting successively the fluorescent lamps on the three supply network phases, or by using the well-known duo-assemblies (consisting in 2 or 4 circuits with fluorescent lamps in parallel, one, respectively 2, of them with inductive ballast and the other one, respectively two, with capacitive ballast), or by combining the two previous solutions: mounting on different network phases of the duo-assemblies.

Each of these systems has its advantages and disadvantages making profitable one or another of these systems. In order to properly compare two lighting systems, there should be taken into account the flicker level of the illumination. Actually, this aspect is not always correctly considered.

2 ANALYSIS OF A LIGHTING INSTALLATION FROM THE FLICKER LEVEL POINT OF VIEW

2.1 Equations for flicker level evaluation in the case of florescent lighting systems

The variation of the luminous flux of a fluorescent lamp can be considered with a proper precision as a sinusoid[2]. So that, it can be decomposed into a constant component (equal to the medium value of the flux for an integer value of periods) and a variable component, which can be substituted by an equivalent sinusoid (with the same effective value).

As it is known, for the evaluation of the flicker level of illumination of a source there is used the amplitude of the equivalent sinusoid of the variable component divided through the constant component.

$$p = \frac{\sqrt{2}E_{v_e}}{E_c} \qquad (1)$$

where:

E_{v_e} is the effective value of the illumination's variable component;

E_c - constant component of illumination.

There are also mentioned in literature those equations for evaluation of illumination flicker level in the case of three sources with staggered fluxes, according to Table 1. These equations are useful for stroboscopic effect evaluation in almost the all practical cases. The „source" term indicates the totality of the lamps having the luminous fluxes in phase.

Table 1 General and particular equations for illumination flicker evaluation

<table>
<tr><th>Resulting illumination flicker</th><th colspan="2">Equations</th></tr>
<tr><td rowspan="4">where:
E_i [lx]- medium illumination produced by source i;
p_i –flicker of luminous flux of source i;
φ_{ik} -arguments' difference between currents of sources k and i.</td><td colspan="2">$$p = \frac{E_v}{E_c} = \sqrt{\frac{\left(\sum_{i=1}^{3} p_i E_i\right)^2}{\left(\sum_{i=1}^{3} E_i\right)^2} - 4\frac{\sum_{i,k=1}^{3} p_i p_k E_i E_k \sin^2 \varphi_{ik}}{\left(\sum_{i=1}^{3} E_i\right)^2}}$$
(2)</td></tr>
<tr><td colspan="2">Particularizations</td></tr>
<tr><td>Lamps of the same color
$p_1 = p_2 = p_3 = p_s$</td><td>Lamps connected to the three phases of the network
$\sin\varphi_{ik} = \sin\frac{2\pi}{3} = \frac{\sqrt{3}}{2}$</td></tr>
<tr><td>$$p = p_s\sqrt{1 - 4\frac{\sum_{i,k=1}^{3} E_i E_k \sin^2 \varphi_{ik}}{\left(\sum_{i=1}^{3} E_i\right)^2}} \qquad (3)$$</td><td>$$p = p_s\sqrt{1 - 3\frac{E_1E_2 + E_2E_3 + E_3E_1}{\left(E_1 + E_2 + E_3\right)^2}} \qquad (4)$$</td></tr>
</table>

In practice, there are some more often met cases that are interesting from the flicker level values point of view. The cases are shown in Table 2.

Table 2 The resulting flicker level for cases frequently met in practice

<table>
<tr><th>No.</th><th>Analyzed case</th><th>Resulting flicker level</th><th>Observations</th></tr>
<tr><td>1.</td><td>Three adjoined lamps connected on the three supply phases</td><td>$p = 0$</td><td>$E_1 = E_2 = E_3$</td></tr>
<tr><td rowspan="2">2.</td><td rowspan="2">Two adjoined lamps connected on two of the three-phase network or in duo-assembly with a lagging of the currents</td><td>$p = p_s \cos\varphi$
(5)</td><td>$E_1 = E_2 = E$;
$E_3 = 0; \varphi_{12} = \varphi = 120^0$.</td></tr>
<tr><td>$p = 0$</td><td>$\varphi = 90^0$</td></tr>
<tr><td>3.</td><td>Ceiling formed by parallel rows of lighting units alternatively connected to the three supply network phases</td><td>$$p_c = p_s \frac{n\sqrt{8n^2 + 5 - 2\sqrt{\left(1+n^2\right)\left(1-4n^2\right)}}}{\left[3\sqrt{\left(1+n^2\right)\left(1+4n^2\right)} - n\sqrt{1+4n^2} - 2n\sqrt{1+n^2}\right]^2}$$
(6)
where:</td><td>By this method the flicker of illumination produced in quite high rooms can be seriously reduced.</td></tr>
</table>

		$n = \frac{d_1}{h}$; d_1- distance between lamps (step disposal); h - hanging high over work plane.	
4.	Parallel rows of lighting units with lamps in duo-assembly alternatively connected on the three supply network phases	$p_d = 0{,}5 p_c$ (7)	Considering the phase lagging between the fluxes of the lighting unit's lamps equal to 120^0, the three sources' illuminations will be given by the half of the sums of illuminations in the case 3.

2.2 Case study

There was achieved the photometric calculus of the installation of general interior lighting system [1], [3] for an industrial hall. The main characteristics of the room are given:

- Dimensions : $L_1 = 37{,}5\ m$; $L_2 = 18{,}5\ m$; $H = 5{,}5\ m$;
- Work category: IV (medium precision working);
- Contrast between detail and background: small;
- Background category: medium, *b* subcategory, $E_{med} = 300\ lx$
- Medium emission of dust and smoke: $k_d = 1{,}5$
- Reflection factors for wall, and respectively ceiling: $\rho_p = 0{,}5$; $\rho_t = 0{,}7$.

The method of utilization factor was applied, covering the following stages:

1) Choosing of the lighting system and lighting source
   The option was for general direct lighting with fluorescent strip lamps of 58 W.
2) Choosing of the lighting units and their placement
   There were mounted lighting units of FIA – 09 – 158 type.
   - The number of lighting units in the same row, N_1, was determined, using the equation (8) :

$$N_1 = \frac{L_1 - L_c}{d_1} + \left(1 - 2k_p\right) \tag{8}$$

   - The number of lighting rows, N_2, was determined, according to equation (9) :

$$N_2 = \frac{L_2}{d_2} + \left(1 - 2k_p\right) \tag{9}$$

where:

d_{1*}, d_{2*} are the relative distances between symmetry centers of two adjoined units in the same row, and respectively between two rows, as following:

$$d_{i*} = \frac{d_i}{h}\Big|_{i=1,2} \approx 0{,}6 \tag{10}$$

where:

h is the hanging high over the useful surface, determined according to equation (11):

$$h = H - (h_c + h_u) \tag{11}$$

3) Luminous flux determination by using equation (12) :

$$\Phi_{tl} = \frac{\Phi_u}{u} = \frac{E_{med} \cdot S \cdot k_d}{u} \tag{12}$$

4) Re-computing of the medium illumination level according to equation (13):

$$E'_{med} = \frac{\Phi'_{tl} \cdot u}{S \cdot k_d} = \frac{N_c \cdot n_{l/corp} \cdot \Phi_l \cdot u}{L_1 \cdot L_2 \cdot k_d} \tag{13}$$

$$\Delta E_{admisibil}[\%] = \pm 10[\%] \tag{14}$$

   - Based on equations (15)…(20) the distances were again computed. Subsequently the plan for placement in the hanging plan of the lighting corps is achieved, according to Figure 1:

$$d_{2\,rec} = \frac{L_2}{N_{2\,rec} - \left(1 - 2 \cdot k_p\right)} \tag{15}$$

$$d_{2*\,rec} = \frac{d_{2\,rec}}{h} \approx 0{,}9 \tag{16}$$

$$d_{1\,rec} = \frac{L_1 - L_c}{N_{1\,rec} - \left(1 - 2 \cdot k_p\right)} \tag{17}$$

$$d_{1*\,rec} = \frac{d_{1\,rec}}{h} = \frac{2{,}39}{3{,}9} = 0{,}6 \tag{18}$$

$$d_{p2} = 0{,}5 \cdot d_{2\,rec} = 0{,}5 \cdot 3{,}7 = 1{,}85\ m \tag{19}$$

$$d_{p1} = 0{,}5 \cdot d_{1\,rec} = 0{,}5 \cdot 2{,}39 = 1{,}19\ m \tag{20}$$

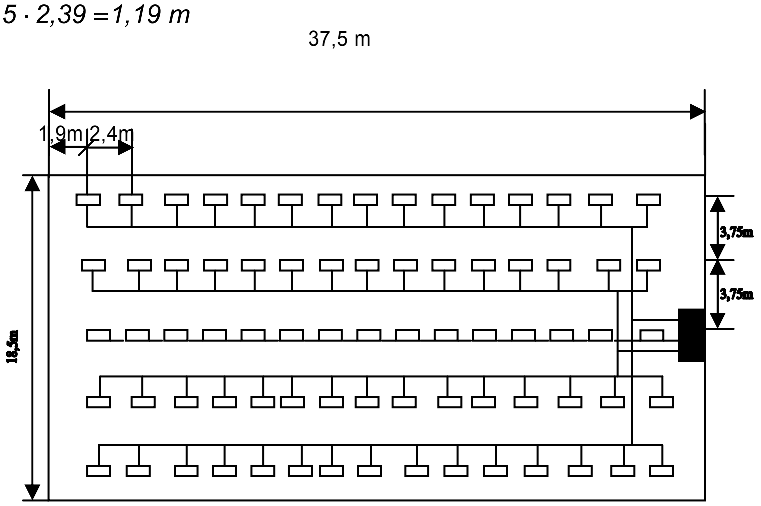

Figure 1 The distribution general electrical (single-wire) configuration of the lighting installation

For the chosen distribution and a known power of the lighting sources the value of direct illumination was determined in different working surface points (i.e. the center of working surface – useful plane) horizontally placed. The following equations were applied [3]:

$$E_i = E_i^{''} \pm E_i^{'} = \frac{\Phi_l}{1000} \cdot \frac{I_{0\gamma}}{2h} \cdot \cos^2 \gamma [\varphi_{l_i^{''}} \pm \varphi_{l_i^{'}} + \frac{1}{2}(\sin 2\varphi_{l_i^{''}} \pm \sin 2\varphi_{l_i^{'}})] \tag{21}$$

2.2.1 Evaluation of illumination flicker level of lighting installation previously presented, for cases frequently met in practice

By considering the fluorescent lamps flicker p_S*=0,4,* there is analyzed the flicker level in that point placed in the hall center, in its useful plan, produced by three lighting units: the central one – row **III**, unit 8 - and the two units in the neighboring – row 7, units 7 and 9. This is because these three units have high illumination values in the hall central point (for angle $\gamma = 0^\circ$ in photometric curve of the lighting unit FIA-09-158), as following:

E_7=E_9=*23,28 lx;* E_8=*41,82 lx.*

For simplifying the calculus equations, there are used the following annotation::

E_7=E_1; E_8=E_2; E_9=E_3.

The calculus of the flicker level was centralized in Table 3.

Table 3 Values of the flicker level determined for different study cases

No.	Analyzed study case	Computed flicker level	Observations	
1.	Case of three adjoined units connected on the three supply phases	0,084		
2.	Case of two adjoined units connected on two of the three-	0,332	for φ=120°	In this case, the flicker level produced by central unit (row no 8)

	phase network or in duo-assembly with a φ lagging of the currents	0,206	(for $\varphi=90^o$)	and one of the neighboring unit (row 7) was studied.
3.	Case of ceiling formed by parallel rows of lighting units alternatively connected to the three supply network phases	0,065	The illumination along the rows can be considered as constant, equation (18) being valid. Each lighting row can be considered as formed by three overlapped continue rows that are equivalent to the three groups of lamps connected on the three supply phases and staggered one by other with the distance between two consecutive lamps. Illumination produced by these equivalent rows are: $E_1=E_3=E_{II}=69,65 lx; E_2=E_{III}=110,48$ lx.	
4.	Parallel rows of lighting units with lamps in duo-assembly alternatively connected on the three supply network phases	0,268	Considering equal to 120^0 the lagging between fluxes of the two lighting rows, the illuminations are: $E_1=E_{II}=69,65 lx; E_2=E_{III}=110,48$ lx.	

2. 3 Conclusions

1. A fluorescent lighting system was dimensioned according to stage presented in &2.2. It includes lighting units with a single fluorescent lamp, placed in 5 parallel rows, each with 15 units. The distances between units are high enough so that in the calculus point the illumination produced by each single unit (adjoined) is substantially different: i.e. $E_1=E_3=23,28$ *lx*, $E_2=41,82$ *lx,* where the units 7(=1), 8(=2) and 9(=3) from row III were considered. These are the relevant sources because they are giving the higher illumination in the central point of useful plane. In these circumstances, the flicker value is $p=0,084$, meaning a decreasing of flicker level with 79%, by comparison with the case of lamps connected on the same phase. In this case the flicker level would be equal to that of one single lamp($p=0,4$).
2. There is considered the same lighting system. For this one the calculus point is placed right on the projection of a lighting unit on the useful plane, while the projection of the other unit is at a distance of the calculus point equal to that between the lighting units. In these conditions, the illumination produced by each unit is substantially different by the others: i.e. $E_1= 23,28$ *lx*, $E_2=41,82$ *lx*, being considered unit 7(=1) şi 8(=2) of row III, because of their highest illumination in the central point in the useful plane. Therefore, the flicker value is $p=0,332$ for $\varphi=120^o$, meaning a flicker level decreasing of 27% by comparison with the case of lamps connected on the same phase, in which the flicker would be equal to that produced of one lamp ($p=0,4$). For a phase lagging of $\varphi=90^o$, the flicker value is $p=0,206$, meaning a flicker level decreasing of 48,5% by comparison with the case of lamps connected on the same phase (flicker would be equal to that produced of one lamp: $p=0,4$).
3. In this case, each lighting row can be considered as being formed by three overlapped continuous rows, equivalent to the three lamps' groups connected to the three supply phases, staggered one of each other at a distance equal with that between two alongside lamps.

Illuminations produced by these equivalent rows are: $E_1=E_3=E_{II}=69,65$ *lx* şi $E_2=E_{III}=110,48$ *lx*, rows II, III and IV being considered because of their high illumination in the central point of the useful plane. The flicker value is $p=0,065$, meaning a flicker level decreasing of 83,75% by comparison with the case of lamps connected on the same phase, in which the flicker would be equal to that produced of one lamp ($p=0,4$).

4. In the case of parallel rows of lighting units with lamps in duo-assembly connected alternatively on the three supply phase, each of illumination is equal to the half of the sum of the others two: $E_1=0,5(E_2+E_3)$, $E_2=0,5(E_3+E_1)$ *şi* $E_3=0,5(E_1+E_2)$. These equalities are available when the illuminations are correspondently equal, meaning the case of an even number of lighting rows or an odd number of lighting rows with two lamps units. The calculus is made for the two lamps of the unit in the central point of the useful plane.

In this case the flicker level will be reduced to the half, $p=0,2$, by comparison with the case of lamps connected on the same phase, in which the flicker would be equal to that produced of one lamp ($p=0,4$).

In the considered case, for different illuminations, $E_1=E_{II}=69,65$ *lx;* $E_2=E_{III}=110,48$ *lx,* the flicker level would be $p=0,268$, meaning a flicker level decreasing of 33% by comparison with the case of lamps connected on the same phase, in which the flicker would be equal to that produced of one lamp ($p=0,4$).

Therefore in the case of a lighting installation with units having one single fluorescent lamp, distributed in odd number by 3 divisible of units on row and odd rows' number, the optimum solution for decreasing of flicker level consists in connecting of the each row's units alternatively on the three supply network's phase.

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SAVING ENERGY AND REDUCING REACTIVE POWER THROUGH OPTIMAL COMBINATION OF FLUORESCENT LAMPS AND MAGNETIC BALLASTS

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ABSTRACT

In the course of increasing importance of energy efficiency it is vital also to consider the energy consumption of lighting. In general, one step to improve lighting efficiency is to shift from magnetic to electronic ballasts, or to compact fluorescent lamps (CFLs), respectively, as far as smaller lamps are concerned. But the improvement is limited, the cost implication is major, and disappointment may arise from poor reliability and EMC problems.

More progress at less cost premium is possible by shifting from the poorest magnetic ballasts (which should no longer be – but still are – on sale in some European countries) to the models with the best available energy efficiency index (EEI).

However, as far as the ranges of small and medium-sized lamps are concerned, these often provide more than one option of combining a specific lamp with a specific magnetic ballasts. Many ballasts are rated for several different lamp wattages or for different lamp types of equal wattages. Some ballasts are specified to feed either one lamp or two lamps simultaneously. Optimizing the selection bears a greater savings potential than either of the above mentioned steps – and may even reduce the first cost investment!

1 MINIMIZING THE NEED FOR REACTIVE POWER COMPENSATION

The lamp voltage across smaller, i. e. shorter fluorescent lamps of the same type family is lower than with the longer types of the same series. Thereby a larger part of the voltage drops across the ballast, and this voltage drop is greatly – in the ideal case would be wholly – inductive. So on the one hand a luminaire with a smaller lamp has a lower active power intake, but on the other hand it has a higher reactive power dissipation. Commonly, both of these two effects lead to a substantially lower power factor for the lower lamp power ratings than for the higher. So, in relative terms, the compensation investment increases inappropriately when selecting small lamp units. Vice versa, it can be reduced to a fraction by selecting the greatest lamp rating that can be connected to one ballast. There are three different approaches, one of which or eventually also a combination of which may lead to such effect:

1.1 Different lamps on the same ballast

Such effect can be observed very clearly on the TC-S lamps with 5 W, 7 W, 9 W and 11 W power ratings, since all of these four models use the same ballast (Figure 1 or Figure 2): As the lamp power rating connected to one and the same ballast increases, the amplitude of reactive power which remains to be compensated decreases (Figure 5).

1.2 A different lamp on a different ballasts

It also remains to be considered whether a different type of lamp with the same power rating can be found but which has a higher lamp voltage. A higher lamp voltage would mean a lower voltage drop across the ballast and thereby a lower reactive power rating of the ballast. At the same time the current would be smaller when the lamp voltage is greater and the lamp power rating remains the same, so this would reduce the reactive power requirement a second time. This is the case, for example, when replacing a linear 18 W T8 lamp with an 18 W TC-D lamp (Figure 7 left) along with the required ballast (Figure 7 top right). The effect can be tremendous and may cut the reactive power by nearly 50% (compare third to fourth measurement in Figure 6).

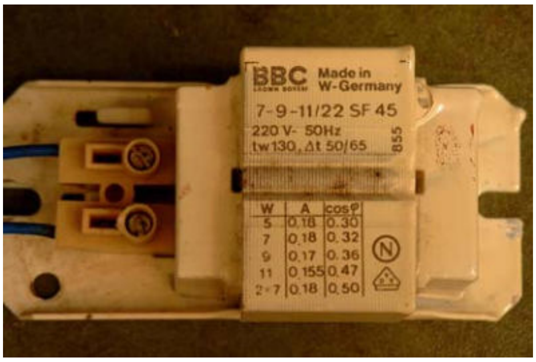

Figure 1 One and the same ballast is designed for four different single lamps and three possible tandem configurations (for reasons of space only one listed here). Current ratings are slightly lower for higher lamp power ratings!

Figure 2 Equivalent ballast as in Figure 1 – later model and different manufacturer. Power factor (λ) ratings are significantly higher for higher lamp power ratings!

1.3 More than one lamp on one ballast

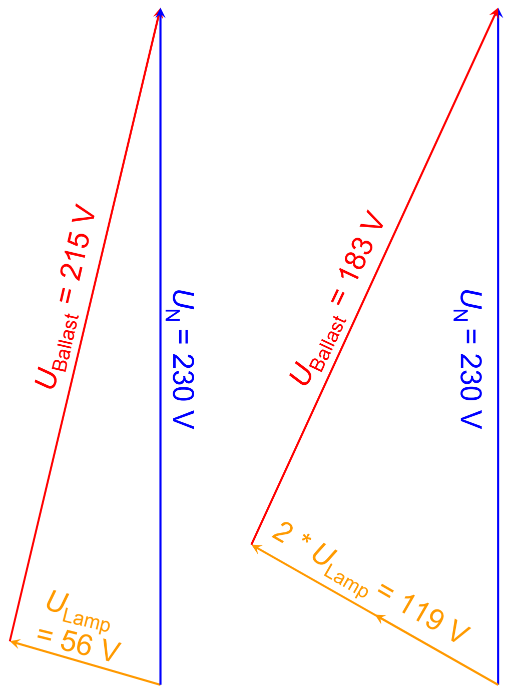

Figure 3 Simplified vector diagram for single and tandem mode operation of a 5 W TC-S lamp – it seems that 2*56 V=119 V in this case but this is because current is slightly lower in tandem mode, which makes lamp voltage greater!

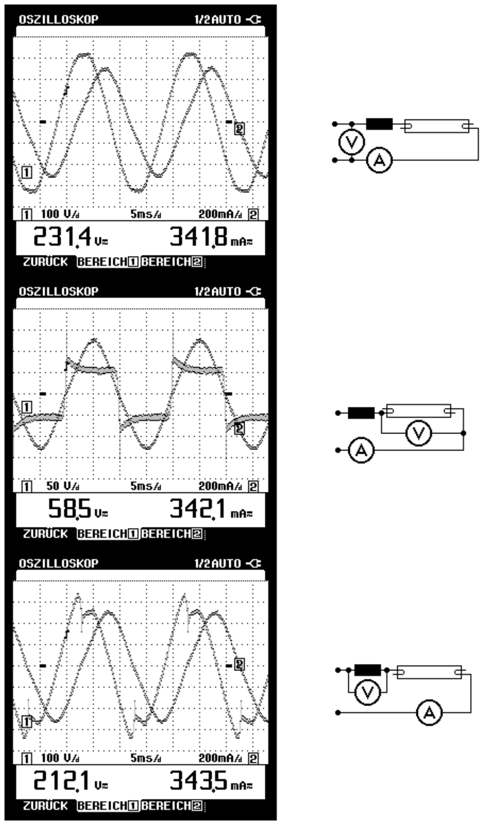

Figure 4 Voltages across a fluorescent lamp and a magnetic ballast

Another option is to operate two lamps on one ballast. Turning back to the TC-S lamps, it remains to be noted that the lamp voltages of the 5 W, 7 W and 9 W models are so low that the common mains voltage of 230 V allows two of these lamps to be operated in series on one ballast. In effect, this doubles the lamp voltage, of course. To be precise, it more than doubles the lamp voltage because of the inverse behaviour of a gas discharge. Since the same ballast is used for this so-called tandem connection as for the single-mode operation, the actual current when operated in tandem lies slightly below the lamp current rating – though not very much, as the inductive voltage drop still prevails and adds orthogonally to the active drop (Figure 3). One of the advantages of this operating mode is that **two** lamps **together** use **less** reactive power than one of them already does in single mode (Figure 5, Figure 6). But it is obvious that this mode does not work on TC-D lamps because their lamp voltages are too high. Rather, one TC-D lamp alone already performs a great deal better than one TC-S lamp alone.

As an aside, it can also be observed in Figure 3 that apparently the right angles, especially in the triangle on the right side, are not really right angles. This is not due to drawing inaccuracy but dates back to the fact that the voltages across ballasts and lamps are highly distorted (Figure 4), while vector diagrams are basically applicable to sinusoidal wave forms only.

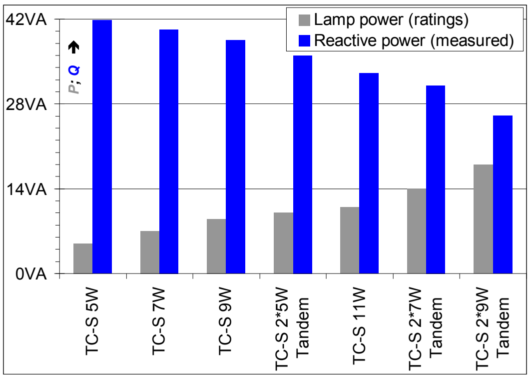

Figure 5 Power factor as the ratio of active power (grey benches) plotted against reactive power (blue benches) for different TC-S lamps from 5 W to 11 W with the same ballast, single and tandem modes

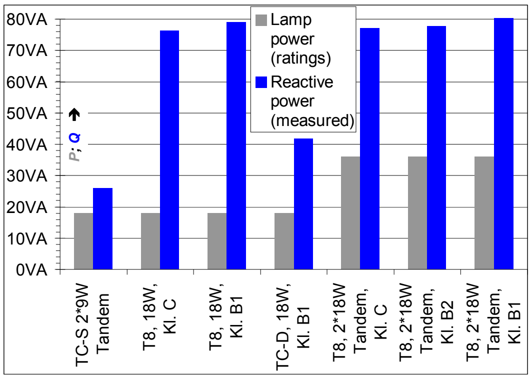

Figure 6 Power factor as the ratio of active power (grey benches) plotted against reactive power (blue benches) for 18 W lamps and different ballasts, single and tandem modes (for comparison, 2*9 W tandem mode also included)

2 MINIMIZING ACTIVE POWER LOSSES IN THE BALLAST AND MAXIMIZING LAMP EFFICIENCY

Figure 7 TC-D lamp 18 W, energy efficient magnetic ballast and electronic ballast for this (top) and B1 magnetic ballast for a commonplace T8 lamp of equal power rating (bottom)

Table 1 CELMA values for smaller lamps

Lamp power rating		Maximum input power of ballast & lamp circuits					
50Hz (magnetic)	HF (electronic)	Class D	Class C	Class B2	Class B1	Class A3	Class A2
5W	4.5W	>14W	14W	12W	10W	8W	7W
7W	6.5W	>16W	16W	14W	12W	10W	9W
9W	8.0W	>18W	18W	16W	14W	12W	11W
11W	11.0W	>20W	20W	18W	16W	14W	14W
18W	16.0W	>28W	28W	26W	24W	21W	19W
36W	32.0W	>45W	45W	43W	41W	38W	36W

Advertisements in favour of electronic ballasts occasionally claim that in magnetic ballasts »up to 30%« of the luminaire's total power intake is absorbed as losses. First of all, it remains to be noted that a statement like »up to«, very popular though it may be, is at the same time totally inappropriate to make any statement at all, unless simultaneously complemented by indicating the mean and the maximum values. The same applies here: The greatest relative losses occur with the smallest lamps. This can be traced back to a law of nature once called »The Paradox of the Big Machine« [1]. In a

58 W lamp, for instance, it is only 13%. So the indication »up to 30%« tells nothing at all. On the other hand, this is even disexaggerated. For instance, when measuring the power shares on a TC-S lamp rated 5 W and operated with a conventional magnetic ballast, a lamp power magnitude of 5.6 W may be found, along with once again the same magnitude of ballast losses, so in this case you may very well speak of 50% losses.

Although the Ballast Directive 2000/55/EC does not cover lamp wattages smaller than 15W, CELMA [2] did include the small wattage lamps into their EEI classification (an extract is shown in Table 1). This makes it easier to compare and assess different modes of operation. Again, there are three possible approaches for optimisation.

2.1 Different lamps on the same ballast

While the lamp voltage across shorter lamps of the same type family is lower than with the longer types of the same series, the current rating for the longer lamps being operated on the same ballast is a bit lower (Figure 1 and Figure 2). However, the ballast losses are approximately proportional to the square of the current. So if you replace the 5 W lamp in one and the same luminaire with a 7 W lamp, which is not a problem at all if only the greater lamp length can be accommodated, under the bottom line you receive more lamp power at lower power loss.

But this is still not the full story, since the lamp voltages across the TC-S lamps rated 5 W, 7 W and 9 W are so low that the common mains voltage of 230 V allows two of these lamps to be operated in series on one ballast. This more than doubles the lamp voltage (Figure 3). As the same ballast is used for this so-called tandem connection as well as for the single-mode operation, the actual current and thereby the resulting power when operated in tandem lie slightly below the ratings. In order to minimize the deviation, the magnetic ballasts are designed in a way so that in single mode the current and power magnitudes are slightly above the lamp ratings. In total, the effect is that the ballast is always less loaded, the more lamp power rating is connected to it. More lamp load leads to an absolute drop in losses and thus, in relative terms, saves duplicate (Figure 8).

Table 2 Comparison of electrical data and light outputs with small fluorescent lamps

Type (device under test)	Metering conditions	Measurements DIAL								Calculated values				
		U V	P_{tot} W	P_{Ball} W	P_{Lamp} W	I mA	U_{Ball} V	U_{Lamp} V	Φ lm	η_{Lamp} lm/W	η_{tot} lm/W	S_{tot} VA	Q_{tot} Var	P_{Loss}/P_{tot}
CFL Megaman 4W		**207.2**	3.43	---	---	29.7	---	---	159.1	---	**46.39**	6.2	5.1	---
	Rated voltage →	**230.0**	3.86	---	---	30.6	---	---	172.9	---	**44.79**	7.0	5.9	---
		253.1	4.30	---	---	31.5	---	---	183.8	---	**42.75**	8.0	6.7	---
CFL Action Sunlight 11W		**207.1**	9.59	---	---	98.7	---	---	479.6	---	**50.01**	20.4	18.1	---
	Rated voltage →	**230.0**	10.82	---	---	102.6	---	---	504.8	---	**46.66**	23.6	21.0	---
		252.9	12.04	---	---	106.5	---	---	529.0	---	**43.93**	26.9	24.1	---
CFL Osram Dulux EL 11W		**207.4**	10.52	---	---	78.0	---	---	593.3	---	**56.40**	16.2	12.3	---
	Rated voltage →	**230.3**	11.80	---	---	80.1	---	---	657.9	---	**55.75**	18.4	14.2	---
		253.3	13.02	---	---	81.9	---	---	706.4	---	**54.26**	20.7	16.2	---
Osram Dulux S 9W		**207.0**	11.05	3.70	7.40	150.0	190.8	58.5	509.0	68.79	**46.07**	31.1	29.0	33.5%
	Rated voltage →	**230.0**	13.29	5.10	8.20	176.0	215.3	56.4	559.9	68.28	**42.13**	40.5	38.2	38.4%
		253.0	16.47	7.30	9.20	212.0	239.2	53.9	612.6	66.59	**37.20**	53.6	51.0	44.3%
2*Dulux S	Rated voltage →	**230.0**	16.64	3.20	13.50	136.6	182.6	119.2	928.4	68.77	**55.79**	31.4	26.6	19.2%

Simultaneously, the lamp efficiencies improve when the lamps are not operated at full power, and inversely efficiencies drop when lamps are driven into the overload range. This was revealed during a measurement carried out by a well respected and independent lighting institute [3], recording not only the electrical values but along with these the light output (Table 2). In this test the 9 W lamp turned out at the end of the scale, since the 5 W and 7 W lamps had already disqualified themselves to participate at all, based on the results of a pre-test displayed in Figure 8.

2.2 Different lamps on different ballasts – comparison also to electronic CFLs

Albeit, the light output efficiency with a tandem connection of two 9 W lamps on one magnetic ballast – and even an old, less efficient one – turned out equal to that of a high-end CFL and 20% better than a cheap CFL from the DIY supermarket! It remains to be stated here that the operation of a CFL is always an operation with an (integrated) electronic ballast! So much about the better lamp efficiency with electronic ballasts. Compared to the single-mode operation of one 9 W TC-S lamp the 2*9 W tandem configuration turned out 25% more efficient – with the same ballast and same lamp(s), after all! However, the light output is a bit less than double that of the single lamp. This remains to be considered when designing a lighting installation.

2.3 More than one lamp on one ballast – good wherever possible

But the tandem connection is also applicable to T8 lamps with a power rating of 18 W. Although in this case different ballasts are meant to be used for single and tandem configuration, the results are similarly profitable. Here, too, the finding is that the power loss in the class B1 ballast attributable to two lamps is even lower than that in the class B1 ballast for only one lamp (Figure 9).
Now there are some more lamp types with a rating of 18 W available on the market, e. g. the TC-D lamp. It has a much higher lamp voltage and can therefore not be operated in tandem mode, but since the lamp voltage under normal operating conditions is greater, the voltage drop across the ballast is smaller. So the required reactive power rating of the ballast is also selected to be accordingly smaller – and thereby the whole ballast is smaller.

But this is not yet all. When the lamp voltage is greater, the lamp current is also smaller and reduces the required reactive power level again. Therefore a magnetic ballast for a TC-D lamp can be built extremely small, also when designed according to EEI class B1 – even smaller than a commensurate electronic ballast (Figure 3)! So especially a luminaire with a TC-D lamp and a high-efficiency magnetic ballast saves space, production costs and energy in one go.

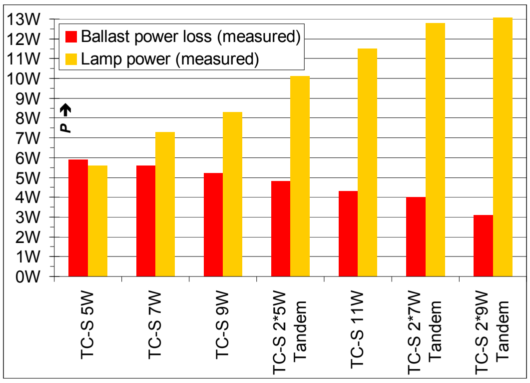

Figure 8 Split of total luminaire power intake for different TC-S lamp configurations with the same ballast

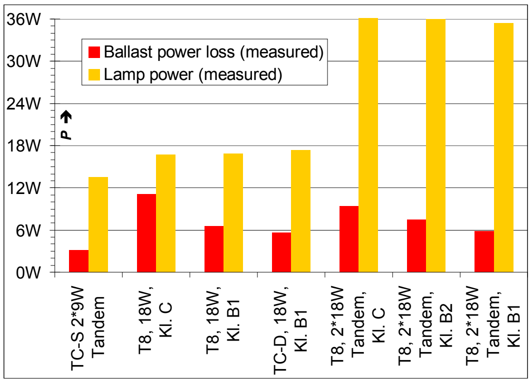

Figure 9 18 W fluorescent lamps in single and tandem mode (for comparison, 2*9 W tandem mode from Figure 8 also included)

2.4 Put them all to the test

The latter finds its confirmation when you add another light output measurement. For this reason the single and tandem operation modes of class B1 magnetic ballasts for 18 W and 2*18 W, respectively, were compared to a single and twin operation mode on an electronic class A2 ballast rated 18 W or 2*18 W, respectively. The results are compiled in 3 blocks of 7 measurements of the light flux Φ each, displayed in Table 3:

- One single T8 lamp,
- two T8 lamps in tandem or twin mode, respectively,
- one TC-D lamp,

with the following ballasts and data:

- Electronic ballast at the lower voltage tolerance limit 90% (207 V),
- electronic ballast at rated voltage (230 V),
- electronic ballast at the upper voltage tolerance limit 110% (253 V),
- magnetic ballast at the lower voltage tolerance limit 90% (207 V),
- magnetic ballast at rated voltage (230 V),
- magnetic ballast at the upper voltage tolerance limit 110% (253 V)
- magnetic ballast at the voltage magnitude where the light output equals that of the same lamp with electronic ballast at 230 V.

For measuring the T8 lamp in single-mode, a single-lamp electronic ballast was used instead of using the twin-mode ballast and connect only one lamp, which would have been possible but could have yielded wrong results. The most crucial results can be found in Table 3, represented as the light efficiency η_{tot} in lumens per watt electrical power intake of the whole lamp and ballast system. The light efficiency cannot be given in per cent because regarding brightness the human eye is differently receptive to light of different colours. Therefore the sensitivity of a standardised average eye is already integrated into the unit for brightness. This unit is called lumen (simply the Latin word for light). So the efficiency of lamps and lumiaires has to be given in lumens per watt. This and only this unit is adequate to assess which technical device provides the greatest brightness per power intake. Of course the share of ballast losses in the total power intake can be given as a percentage – as done in the last column of the table. However, with the electronic ballasts the required measurement of the lamp power, the ballast output power to the lamp so to say, was not possible due to the high output frequency. Therefore the efficiency η_{Lamp} of the lamp alone could not be calculated – but which is not relevant for the end user nor for an assessment of overall efficiency.

Table 3 Compilation of measuremets on 18 W fluorescent lamps

Type (device under test)	Metering conditions	Measurements								Calculated values				
		U V	P_{tot} W	P_{Ball} W	P_{Lamp} W	I mA	U_{Ball} V	U_{Lamp} V	Φ lm	ξ_{Lamp} lm/W	ξ_{tot} lm/W	S_{tot} VA	Q_{tot} Var	P_{Loss}/P_{tot}
18W T8 lamp electronic ballast VS 188314, EEI=A2		**207.0**	19.10			98.4			1382		**72.34**	20.4	7.1	
	Rated voltage →	**230.0**	19.13			90.6			**1381**		**72.19**	20.8	8.3	
		253.0	19.10			85.0			1383		**72.41**	21.5	9.9	
18W T8 lamp magnetic ballast VS 164572, EEI=B1		**207.0**	20.96	4.70	16.23	304.7	186.6	62.7	1195	73.65	**57.03**	63.1	59.5	22.4%
	Rated voltage →	**230.0**	24.47	6.24	18.21	354.6	211.2	60.6	1320	72.50	**53.95**	81.6	77.8	25.5%
	Φmag=Φelec →	**241.7**	26.18	7.21	18.94	382.2	223.8	59.0	**1381**	72.91	**52.75**	92.4	88.6	27.5%
		253.0	28.19	8.22	19.94	410.6	235.5	58.2	1438	72.13	**51.02**	103.9	100.0	29.2%
2*18W T8 lamps electronic ballast VS 188316, EEI=A2		**207.0**	36.59			181.0			2816		**76.96**	37.5	8.1	
	Rated voltage →	**230.0**	36.58			164.2			**2817**		**77.00**	37.8	9.4	
		253.0	36.53			149.7			2815		**77.07**	37.9	10.0	
2*18W T8 lamps magnetic ballast Helvar L36, EEI=B1		**207.0**	33.70	3.33	30.37	296.0	146.9	62.2	2330	76.72	**69.14**	61.3	51.2	9.9%
	Rated voltage →	**230.0**	42.24	5.34	36.90	379.0	179.2	58.6	2809	76.12	**66.50**	87.2	76.3	12.6%
	Φmag=Φelec →	**230.8**	42.70	5.58	37.12	387.0	180.9	57.9	**2817**	75.90	**65.98**	89.3	78.5	13.1%
		253.0	50.48	8.20	42.28	473.0	208.7	54.5	3169	74.95	**62.77**	119.7	108.5	16.2%
18W TC-D lamp electronic ballast Osram QT-T/E, EEI=A2		**207.0**	16.09			78.5			1064		**66.13**	16.2	2.3	
	Rated voltage →	**230.0**	17.75			78.2			**1173**		**66.11**	18.0	2.9	
		253.0	19.84			79.8			1276		**64.34**	20.2	3.7	
18W TC-D lamp magnetic ballast VS 508922, EEI=A2		**207.0**	17.71	3.33	14.40	165.7	165.6	107.4	982	68.19	**55.44**	34.3	29.4	18.8%
	Rated voltage →	**230.0**	21.69	4.96	16.70	204.7	195.1	101.7	1117	66.87	**51.48**	47.1	41.8	22.9%
	Φmag=Φelec →	**241.4**	23.86	6.01	17.80	225.7	208.9	99.0	**1173**	65.93	**49.18**	54.5	49.0	25.2%
		253.0	26.53	7.48	19.05	250.5	222.4	96.5	1229	64.51	**46.32**	63.4	57.6	28.2%

2.5 Results

The following results can be read and conclusions drawn from the table:

1. The advantages of the tandem configuration and of the TC-D lamp already found in the pre-measurement with respect to reactive power find their confirmation.
2. The magnetic ballast power loss increases highly over-proportionally to the systems operating voltage. At 253 V the power loss is usually double as high as at 207 V. Together with the slight increase of lamp efficiency η_{Lamp} the voltage reduction practice results as an efficient means of loss reduction for all magnetic ballast configurations.
3. When operated on rated voltage, a single 18 W T8 lamp is about 4% brighter with electronic than with magnetic ballasts. (This is the inverse result as found earlier with 58 W lamps [4], where the light output was 4% higher with magnetic ballasts.) On the twin electronic ballast compared to the magnetic tandem configuration the difference is negligible. The operating voltage on the tandem only has to be turned up to 230.8 V before the same brightness as with the electronic twin ballast is achieved.

Therefore when assessing the light efficiencies of the single-modes, two different approaches have to be considered:

4. Either the luminaires are operated at rated voltage in either case. The comparison will then be closer to what will usually happen in practice, though it is not objective. We are then talking about a systems power of 19.13 W with electronic ballast versus a systems power of 24.47 W with magnetic ballast. A payback time for the well over 5 W saved cannot be given, as the impact of the price premium for an electronic ballast upon the price for a complete lighting installation is subject to substantial variances. However, with an energy price of 10 c/kWh it takes 1872 operating hours to save the first Euro. This cornerstone can be used for the according conversions: At 5 c/kWh it takes 3744 hours, at 20 c/kWh it takes 936 hours to save 1 Euro and so on.
5. Or you calculate objectively. Nobody will increase the line voltage in order to achieve precisely the same brightness with the used/planned magnetic ballast as with the electronic ballast not used. The lighting planner is unlikely to include a few more lamps if the decision for magnetic ballasts has been taken, because the difference is so insignificant, but if done, then this would have approximately the same effect as if the same number of lamps were connected to a line voltage of 241.7 V, which would be equivalent to the difference between 19.13 W and 26.18 W systems

power, say 7 W. So the real, effective »savings cornerstone« is then 1418 operating hours per Euro saved at 10 c/kWh.

6. Moreover, it becomes obvious that the limits of the EU directive, which are 24 W systems power in class B1 and 19 W in class A2, are in principle not complied with, neither by the magnetic nor by the electronic ballast. Only by being rather lenient accounting to metering inaccuracy the EEI classes can still be seen as just about fulfilled.

But by all means this mode of operation does not represent the optimal combination. The power loss in a 36 W ballast is not double the loss in an 18 W ballast (»Paradox of the Big Ballast«), about the triple advantage of the tandem mode not even to speak. Rather, the respective conclusions to above items 4 to 6 for the twin or tandem modes of two 18 W lamps will be:

7. Comparing the operation at rated voltage in either case, the difference between magnetic and electronic ballast operation is now only more some 2.5 W per system, whereas a system now comprises two lamps and one ballast (and two starters in the case of the magnetic ballast); say, the difference is only more 1.25 W per lamp. So with an electricity price of 10 c/kWh it takes 4000 operating hours to save one Euro per ballast or per every 2 lamps, respectively. Or, selecting a different example: At uninterrupted permanent duty with 8760 h/a and an electricity price which is usually quite inexpensive for such use, e. g. 6 c/kWh, one electronic ballast saves approximately one Euro per year.
8. Since brightness with magnetic and electronic ballast is almost equivalent at rated voltage, no distinction needs to be made and above values of point 7 still apply, which facilitates the comparison.
9. Although the directive provides a separate line with limits for two lamps being operated on one ballast, the values per lamp are identical to those for the single-mode operations as under item 6. Very much unlike with the configuration described under item 6, however, the limits are by far kept here: The electronic ballast remains well over 1.5 W below the class A2 limit, the magnetic ballast even falls 3.5 W below the B1 limit.

On the TC-D lamp the following can be observed:

10. The efficiency is about 5% to 10% poorer than that of the T8 lamp. This may be due to the compact design which leads to a part of the light generated hitting the lamp itself.
11. Here the use of the electronic ballast results in an uncommonly high saving of 28% on equal voltage or 34% at equal light output, respectively. It by far fulfils the requirements for class A2, while the magnetic one does not really match the limit for class B1. This magnetic ballast may have been designed a bit too small in favour of facilitating the design of very small luminaires (Figure 7 top right), and in electrical engineering skimping on active material (copper and magnetic steel) always comes at the price of reduced efficiency. It has to be considered, however, that these two measurements possibly cannot really be compared because they could not be carried out on the same lamp. The TC-D lamp for magnetic ballast operation is equipped with an integrated starter and therefore has only two connections (Figure 7 left). The starter is wired internally. The version for electronic ballast operation requires four pins.
12. Unlike the other electronic ballasts used in this test, the one for this lamp is not equipped with an electronic power stabilisation to offset variances of the input voltage.

3 CONCLUSIONS

It has become obvious that the difference between the poorest and the optimal combination of lamps with magnetic ballasts covers a much wider range than the transition from magnetic to electronic ballasts. Electric losses may range as high as 50% and as low as 14% of the measured total luminaire or systems power. It is therefore important to select the right combination of a lamp and ballast, since in a variety of cases different lamps can be operated with the same ballast and vice versa. The overall light efficiency varies even wider, therefore:

- Wherever the opportunity exists to vary the combination of lamps and ballasts, as a rule it is better to operate a higher lamp power rating on a given ballast than a lower rating.
- Wherever possible, the tandem configuration should be preferred to single-mode (Figure 10, Figure 11).
- Adding to this, best available EEI ballast classes should be selected (although the impact of this point is minor than that of the former two).

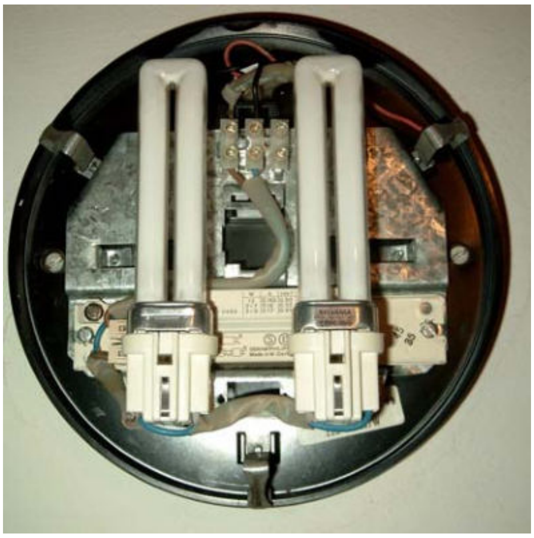

Figure 10 One ballast suffices for two smaller lamps, reducing the levels of both reactive power and active losses below the level which otherwise one lamp alone would cause

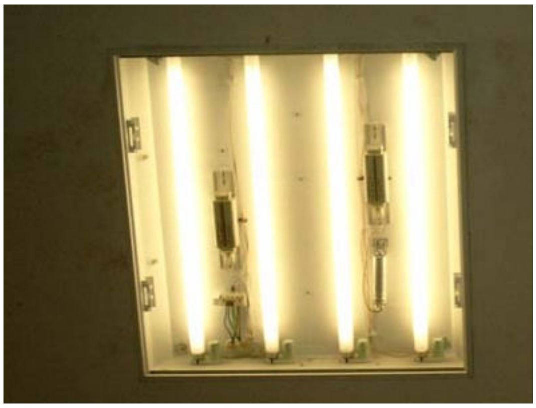

Figure 11 Two ballasts and one capacitor are enough to operate four 18 W lamps in this luminaire very economically, both from an energy efficiency **and** from an initial investment cost viewpoint

- However, to identify a payback time for the use of electronic ballasts is difficult, as the pricing often includes other factors in addition to the price difference between magnetic and electronic ballasts. Some luminaires are only available with electronics. It may even require a surcharge to get magnetics as an extra. In such cases it seems to be time to look for a different supplier if you prefer magnetic ones for reliability or EMC reasons. However, when considering to pay a price premium for electronic ballasts in order to improve energy efficiency, it remains to also consider that, depending on the assumptions you make, it takes between 1000 and 10,000 hours of operation to save 1 Euro of electricity costs.

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OPTIMIZING SPECTRAL POWER DISTRIBUTION OF CAR HEADLAMP LIGHTING

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ABSTRACT

There are very few investigations on best spectrum for mesopic visibility and even less data on the spectrum of discomfort glare. We have studied these two perceptions and came to the conclusion, that it is not enough to optimise for the combined photopic and scotopic luminosity functions but the chromatic components have to be taken into consideration too.

In this paper investigations to determine optimum SPD for mesopic conditions providing good visibility and low glare will be described.

Keywords: glare, visibility, night-time driving, mesopic vision, spectral sensitivity

1 INTRODUCTION

Good vision is highly essential when driving a motor vehicle. Night-time driving takes place under changing mesopic conditions. Vehicle headlamps illuminate a small (mainly para-foveal) part of the visual field, street lighting produces a more or less even background illumination, and the headlamps of approaching vehicles modulate the state of adaptation of the driver continuously in a very unpredictable way, as well as causing glare for the driver.

Headlamp glare is an issue that has grown in terms of public awareness over the past decade. Developments in light source technologies and optical design have resulted in headlamp systems with higher efficiency, smaller size, as well as with different spectral power distributions.

High intensity discharge (HID) headlamps produce higher discomfort glare, than the TH (tungsten halogen) headlamps[1,2] , even if the glare illuminance is held constant. This is ascribed to differences in spectral power distribution (SPD).

At present, car headlamps await the next revolution with light emitting diodes (LED's) soon to become an alternative light source. Some observations show[3,4,5] that headlamps with LED's will cause more glare than headlamps with the other two types (TH, HID) of sources. This is based on the fact that presently available LED's have a chromaticity, which is bluer than that of the other lamp types. At this stage the LED white light can still be tailored to get best (mesopic) visibility and minimum of glare. But for this, the proper spectral sensitivity to mesopic visibility and discomfort glare has to be known.

2 SPECTRAL SENSITIVITY OF VISIBILITY AND DISCOMFORT GLARE

For mesopic visibility there are two recent recommendations, those suggested by the group at the Rensellaer Institute of Technology[6] and by the so-called MOVE project consortium[7]. Both of them suggest to use in the mesopic range spectral responsibility functions composed from the $V(\lambda)$ and the $V'(\lambda)$ functions. Differences are mainly whether for foveal vision one should use in all cases the $V(\lambda)$ or even in that case a composite spectrum is a better approximation.

Regarding glare perception in night-time driving situation it has been found that discomfort glare (DG) is the main cause produced by the car headlamps of oncoming vehicles[8]. Typical eye level glare illuminance from oncoming headlamps were found during the early 1990's to range up to 10 lx in normal driving conditions at night[9]. At this time conventional halogen headlamps were the primary sources of forward lighting. According to Bhise at al.[10] 0,1 lx at the eye is the threshold from non-glaring to glaring conditions, when the illuminance from a glare source begins to become uncomfortable. It was found that a value of 3 to 10 lx is close to the illuminance at which discomfort becomes unacceptable[11,12,13].

During the past ten years gas discharge lamps (HID) have become the favourites in car headlamps, having a higher correlated colour temperatures (CCT) than TH lamps but causing problems with increased DG. From this one concluded that despite the fact that higher CCTs can be of advantage to mesopic visibility, the increasing DG causes problems. To find an optimum compromise between mesopic visibility and DG their spectral responsivity has to be known.

2.1 Visibility experiment

In contrary to literature data we have found that both on-axis and off axis threshold contrast visibility is better described by functions where also the chromatic channels of the human visual system are taken into consideration. Figure 1 shows e.g. the spectral responsivity function for off-axis threshold contrast sensitivity at 0.1 cd/m^2 photopic luminance levels. Maxima in the curve can be seen that makes impossible to construct such a curve from simply adding $V(\lambda)$ to $V'(\lambda)$.

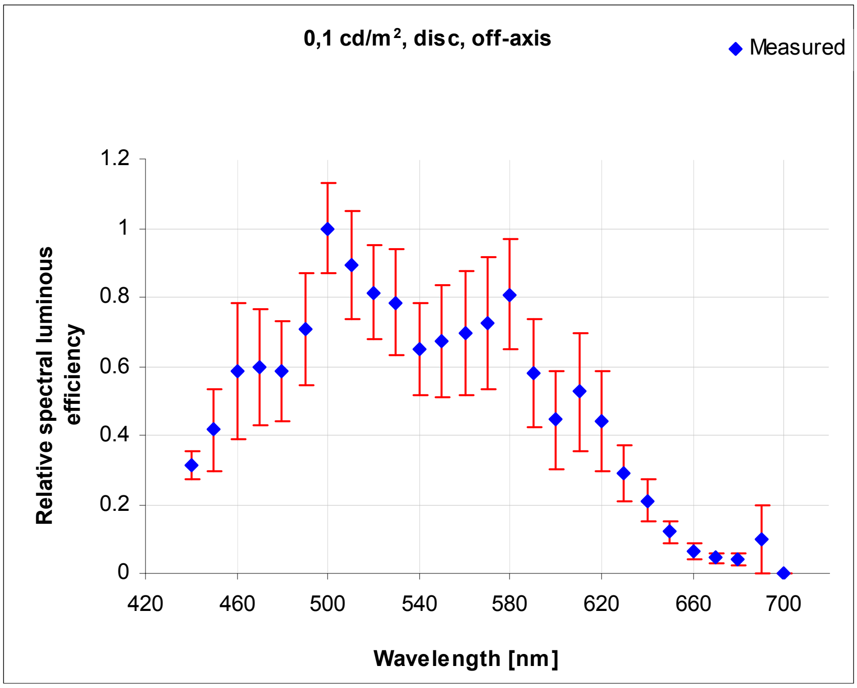

Figure 1 Spectral luminous efficiency function for threshold contrast sensitivity at 0,1 cd/m^2 photopic luminance level, ♦: measured value, mean of ten persons, ⊥: 95% confidence intervals.

2.2 Glare experiment

Experiments were conducted under laboratory conditions to define the spectral dependence of discomfort glare. The glare source was illuminated by an extra high-pressure Xe lamp, the light of which was focused via a relay lens and interference filters to monochromatize the radiation onto a holographic diffuser that served as the glare source, see Figure 2. An adjustable diaphragm was used to set different glaring intensities.

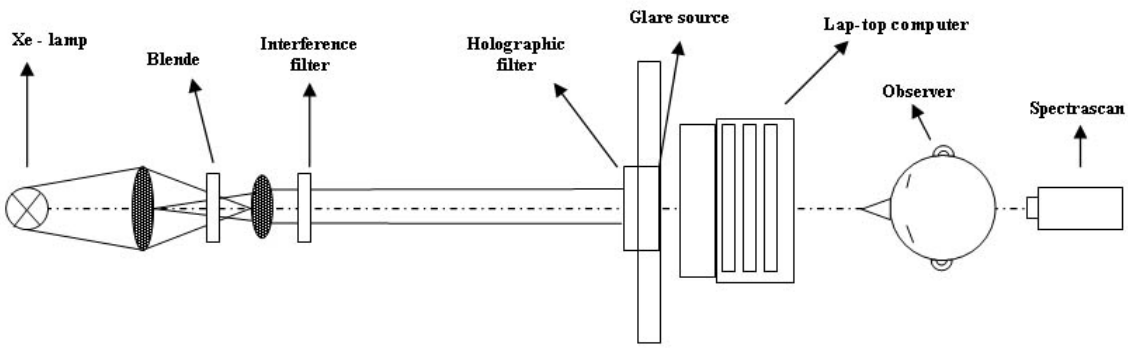

Figure 2 Set-up of the visual experiment to investigate the spectral dependence of discomfort glare (not to scale).

The glare source was adjusted so that the observer could see it under an angle of two degrees from an appropriate distance, approximately 5 degrees above the viewing direction. Other parts of the screen were black. Before the experiment the test person was seated in the test chair in front of a laptop computer and the room lighting was set to a dim level (approximately 10 lux horizontal illuminance on the computer keyboard), and the subject was instructed to work on the computer. Then the experiment leader selected an interference filter and the test person was asked to set the disturbing glare level (level 3 on de Boer scale) with the help of the adjustable diaphragm.

To test whether the set glare level was still only discomfort glare, or the glare influenced the perception of a task on the computer, different tasks had to be performed by the observer. The analysis of these showed that at the set glare level the glare had no short-term disability effects.

The experiments were carried out by 10 observers at wavelength between 420 nm and 660 nm in 10 nm steps. The experiment was repeated several times with each interference filter in the light path of the glare source. The spectral radiance was measured with a PR 705 spectro-radiance-luminance meter. Results are shown in **Figure 3** by the diamonds: ◆.

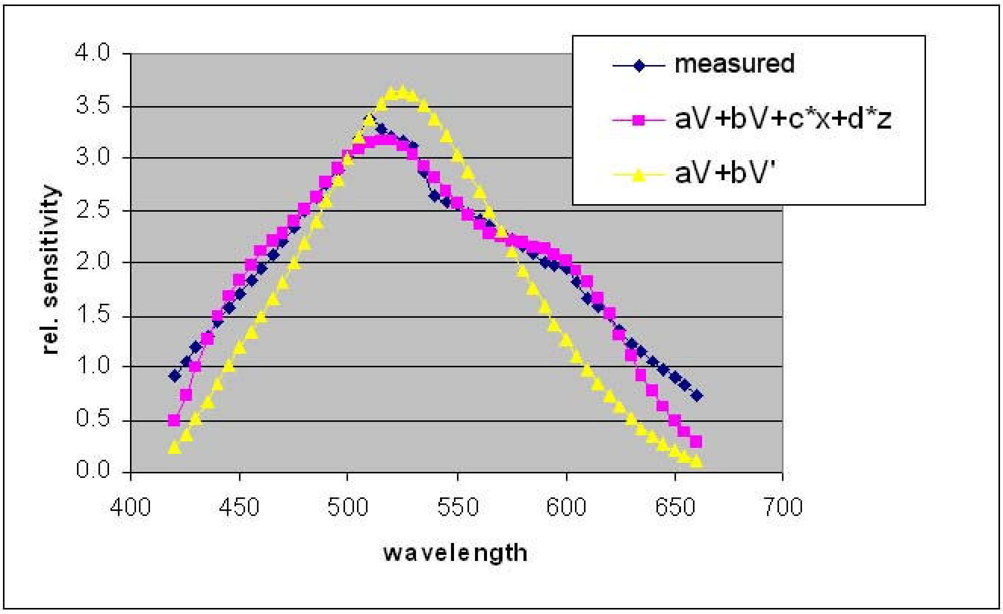

Figure 3 Spectral glare responsivity (◆), best approximation using V(λ) and V'(λ) (■), and using also the $\bar{x}(\lambda)$ and $\bar{z}(\lambda)$ functions.

4 DISCUSSION AND CONCLUSIONS

In **Figure 3** we also show the best mean square approximation one can achieve using the $V(\lambda)$ and the $V'(\lambda)$ functions (■), and composing a spectrum using all three colour matching functions and the $V'(\lambda)$ function. The best approximation could be achieved with the following equation:

$$0{,}11V(\lambda) + 0{,}56V'(\lambda) + 1{,}50\ \bar{x}(\lambda)$$

As can be seen using all colorimetric and photometric information a much better approximation can be achieved. This is similar to the situation regarding mesopic visibility, but the coefficients needed are different.

The experiments were conducted in dim surround. No main lights were on, the observer adapted to the dim (approximately 10 cd/m^2) computer screen and the glare source. Peak luminance values of the glare source were well in the photopic luminance range, i.e., ten to a hundred cd/m^2.

Comparing our results with those in the literature[14] one can state that glare spectral sensitivity can not be described by a simple addition of the $V(\lambda)$ and the $V'(\lambda)$ functions. Our results show a broad spectral responsivity curve that peaks in the blue-green region of the spectrum; we suppose that also in the glare sensitivity all three types of cones participate.

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FIELD MEASUREMENT FOR STREET LIGHTING – STUDY CASE IN LETCANI, ROMANIA

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ABSTRACT

The paper present some results obtained with an original device dedicated to the street lighting survey. Starting from actual regulations, the survey of the street lighting becomes very important. Unfortunately, there are not accessible practical methods to realize a real monitoring of this service The general regulations, established by the Law 51/2006, are very well detailed in the Law 230/2006, applicable starting from 27 March 2007. Using CIE Technical Report TC 5.14 "MAINTENANCE OF OUTDOOR LIGHTING SYSTEMS" and EN 13201-4:2003, on impose to realize measurements and evaluate the street lighting performances in Lețcani village, Iaşi county, Romania. The paper includes some results, which will be used for the modernization of the street lighting.

1 INTRODUCTION

In order to improve the night vision in Lețcani village, on the DE 583 high speed road, some quantitative evaluation was necessary. In order to realize field measurement, the proposed device must be portable, and only few examples was found. After the need is established, the configuration of the measurement system can be done. For the feasibility reasons, the specific legislation is essential, and for that reason some positive example was analyzed.

2 THE DATA ACQUISITION SYSTEM FOR FIELD MEASUREMENT

In [1] it was presented some contribution, but no results was availlable. In [2] we find an example about the huge problem represented by the field measurement of luminaires. The City of Akron Ohio was faced with the need to inventory and spatially locate its street light assets in a short amount of time. Using a combination of technologies (using digital photography and GPS), the City was able to quickly and accurately complete a street light inventory of more than 25,000 poles. Field data capture was facilitated by GPS and digital photo/attribute capture. Short ramp up times for field workers and high data collection rates **(one feature/minute)** allowed the survey to be completed ***in three months***. Starting to this, the question is what will be the time for the measurement of the efficiency of the street lighting? For the particular light system, the speed of **one feature/minute** is acceptable, because the number of functioning luminaire is very small: nearly 40. But the reason to propose a specialized data acquisition system, functioning in an ongoing vehicle, remain the objectiv to realize a field monitoring of the streets.

The system for street lighting monitoring consist in a illuminance meter, a dedicated Data Acquisition System, with manual or automatic command for sampling (taken from a supplementary wheel) and a Data logger system with processing and visualization capability.

The block diagram of monitoring luminance systems is presented in Figure 1 [1]:

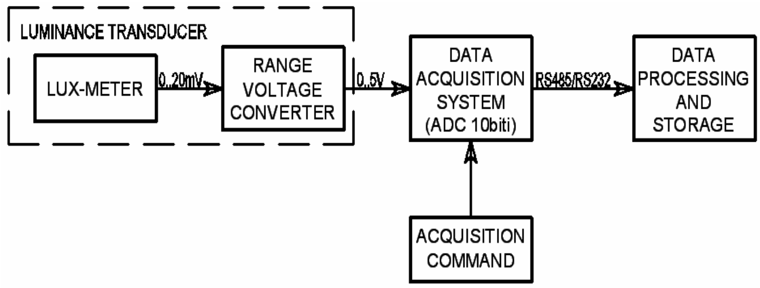


Figure 1 Block Diagram of the system

For illuminance measuring it was used a digital luxmeter HT-1065 having and analogue output. For this applications, working in night conditions, it was used only the 0.. 200 lx domain, with 0 … 20 mV output (!). For the future applications, the detection of the multiplication factor is needed.

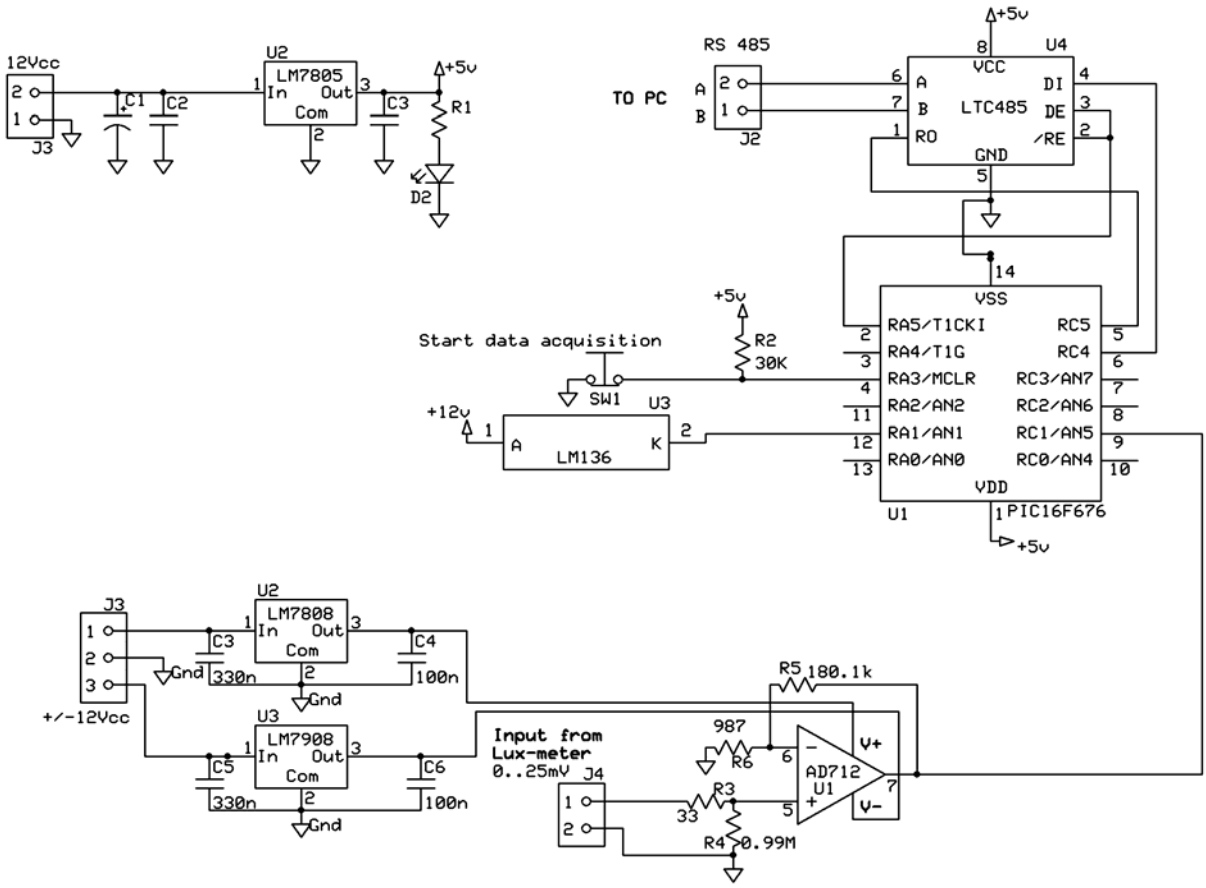
For acquisition and memorize the readings on PC, we used a system based on microcontroller PIC16F688 on 14 pin, with analogue/digital converter on 10 bit and a serial communications that support standard RS232 or RS485.

The main features of the High-Performance RISC CPU are:
- Operating speed:- DC – 20 MHz oscillator/clock input
- Interrupt capability: 8-level deep hardware stack

Special Microcontroller Features
- Precision of Internal Oscillator: Factory calibrated to ±1%
- Software selectable frequency range of 8 MHz to 31 kHz
- Crystal fail detect for critical applications
- Wide operating voltage range (2.0V-5.5V)
- Flash/Data EEPROM retention: > 40 years

Peripheral Features
- 12 I/O pins with individual direction control:
- A/D Converter: 10-bit resolution and 8 channels
- Supports RS-485, RS-232, and LIN 1.2
- Auto baud detect and Auto-wake-up on Start bit

Figure 2 System Electrical Diagram



The algorithm of acquisition system is presented:

a) At the starting moment, A/D converter is initialized, together with serial communication.

b) Waiting period, for the command impulse for the acquisition ;

c) When the acquisition is ON, on select the entrance converter A/D connected to luxmeter, and after that we start the acquisition;

d) At the end of conversion, an interruption is generated, and the data are sent through serial communication to PC;

e) On PC, the serial communication takes the data and write a indexed file;

f) go to step b.

Data acquisition from luxmetter analogue output impose to realize a conversion from 0.. 20mV to 0..5V. To solve the problems already shown in [1], it was chosen the operational amplifier AD712. Because the level of the input is extremely feeble (20 mV for 200 lux, but for an improper street lighting system, the real level goes to 1 mV or less), the real gain was calculated using [3]. In Figure 3 are presented the results based on the resistors measurement (R_G, R_{FB}, R_{REF}), avoiding the difficult measurement for the input signal.

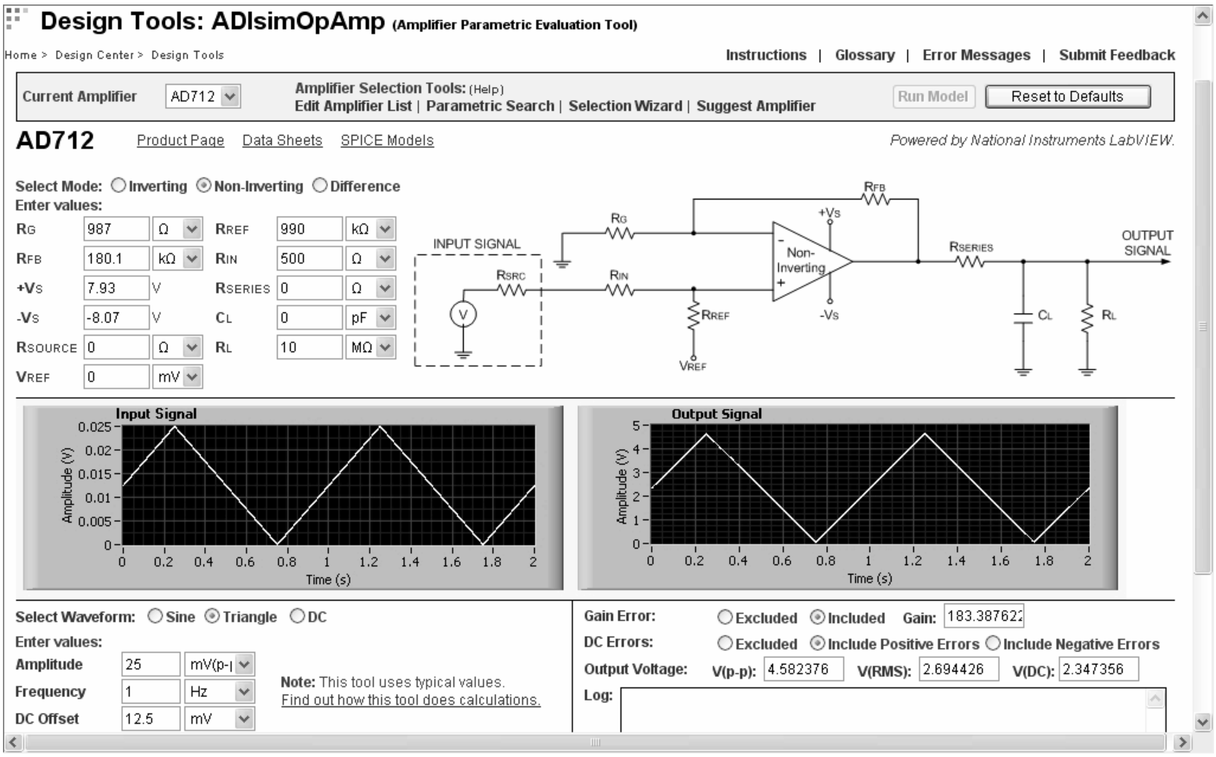


Figure 3 Tuning the operational amplifier AD712.

3 THE QUANTITATIVE APPROACH OF STREET LIGHTING

A particular street was analyzed (European road 583 in Lețcani village, between km 56+550 and km 60+379).

The street lighting is realized on the 20kV aerial power line, with 12 m pillars. But the luminaires are mounted only at 6 m height. The distance between pillars is about 33m, but only one of two pillars are equipped with luminaire. The optical quality of the luminaires are very low (old type PVA).

The lighting effect is negative from the first observation. Supplementary, some observation are possible:

- The one-sided mounting is not recommended for M2 road
- The mounting height is totally unacceptable (minimum 10 m must be imposed, for a pillar retreat of 0,8m)
- The distance between luminaire is 66m, and the road is practically in perfect dark, as shown in the measurements (Figure 4)
- The glare is present, with an excessive effect

The poor quality are obvious (also in Figure 5), but the measurements are useful to give a quantitative approach, necessary to impose the modernization of the street lighting.

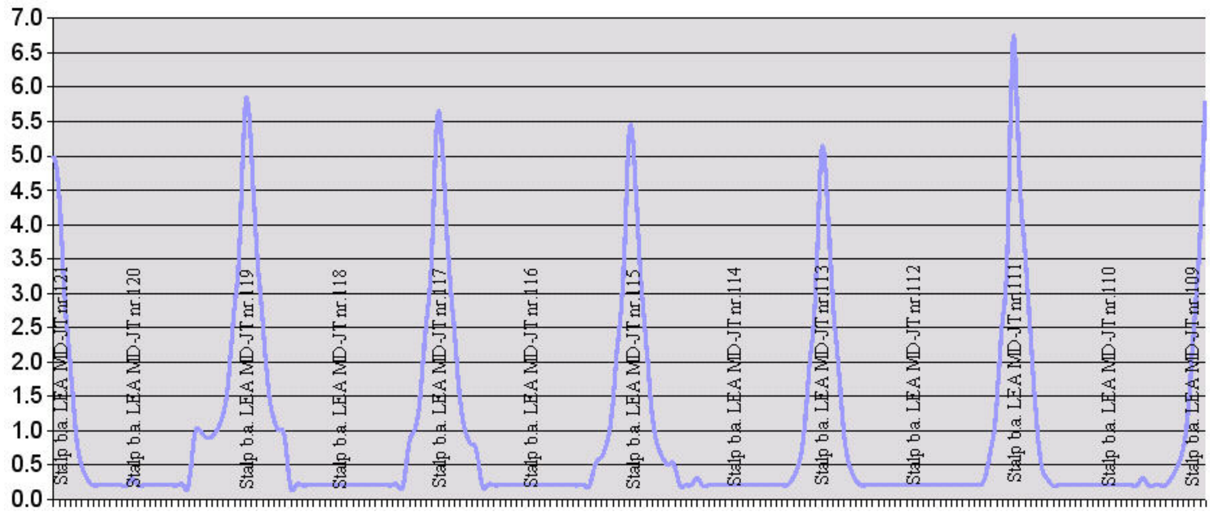


Figure 4 Field measurements for illuminance (lux)

Figure 5 The local effect of the luminaire and the glare

5 THE REGULATIONS IN THE FIELD OF STREET LIGHTING MANAGEMENT

In [7] we can find specific aspects about measurements taken from a moving vehicle. The main differences between dynamic and static measurements are:

- the number of measurement points is greater in the case of dynamic measurements
- the requirements in EN 13201-3 for observer position and location of grid points may be more difficult or impossible to meet in the case of dynamic measurements.

To produce useful and reliable results a dynamic measurement system shall:

a) for every measurement point, be able to link the position of the photometric head in terms of height, and transverse and longitudinal distances or coordinates to a datum such as the kerb; in this study case (Lețcani) , some corrections was possible because the pillar position was obvious (figure 4)
b) minimize any effects, such as vehicle shadow, light reflection, and electronic noise, the vehicle may have on the detector readings;
c) be equipped with photometric heads conforming to the requirements specified in clauses 7 (for illuminance) and 8 (for luminance metering, not applicable in this case).
Measurements from a moving vehicle should include the information listed in A.11 [7]:

- Precautions to allow for transmission loss by windscreen, if present: It was not necessary, because the sensor was outside the vehicle.
- Method of measurement including method of allowing for vehicle shadow: It was used a long support (3 m), but the solution must be improved.

We have some new elaborated general regulations [4] for the public sector, in witch the public lighting benefits a special law [5].

The implementation of the Street Lighting Management system will be a compulsory initiative for user group owned by local authorities. One of the primary aims of the author is to provide a platform to help to promote expertise based on measurements. This is viewed as being the key to providing successful services to the public.

Some important [6] condition must be follow by the street lighting management system:

- Compliance with government regulations.
- Flexible street lighting inventory management system incorporating a facility to ***import street registered and measured*** data.
- Problem reporting / customer care and contact tracking.
- Fault recording with associated work issue, tracking, recording and payment.
- Planned maintenance management, including automatic generation of bulk action jobs, with associated work issue, tracking, recording and payment.
- Cost management and analysis.
- Guarantee management.
- Secure contractor subsystem through which maintenance contractors can process and record work in relation to issued work orders.
- Test recording facilities.
- Extensive reporting facilities, including energy utilization evaluations and full system auditing.

6 CONCLUSIONS

The field measurements for street lighting are very important not only for the first evaluation, but also for street lighting management. This paper present some constructive details of an original measuring system, functioning in a vehicle, permitting to obtain a fast evaluation of the street lighting in Lețcani, Romania.

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FLUORESCENT DAYLIGHT CONTROL SYSTEM BASED ON B-SPLINE LIKE NETWORK WITH GAUSSIAN-TYPE BASIS FUNCTIONS

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ABSTRACT

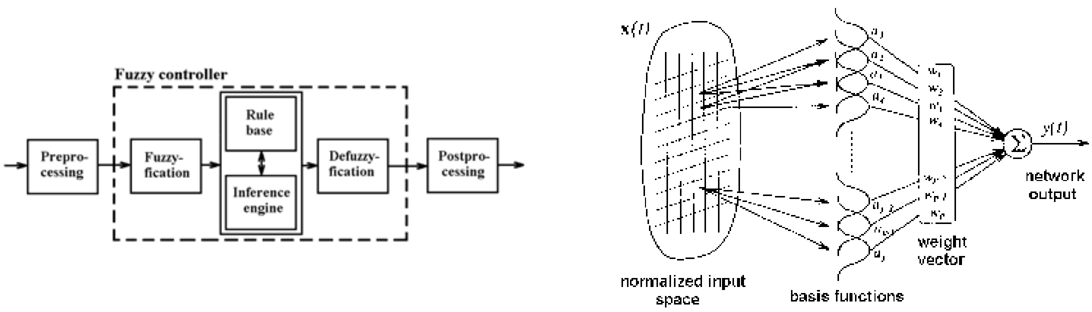
The paper describes the design, the implementation and the tuning of a fuzzy-neural controller used in an automatic daylight control system. The automatic lighting control system (ALCS) attempt to maintain constant the illuminance at the desired level on working plane even if the daylight contribution is variable. Therefore, the daylight will represent the perturbation signal for the ALCS. The mathematical model of process is unknown. The applied structure of control need the inverse model of process. For this purpose it was used an experimental model of process, a look up table (LUT) of measured data at the input and the output of process. The transformation given by the LUT is not single-valued, so this inverse model obtained by using the LUT is a gross approximation of the real inverse model of process. Even if the inverse model of process is not the best solution, a set of settings for fuzzy-neural controller, as ALCS satisfies the imposed performances, was obtained.

1 INTRODUCTION

The ability to learn highly nonlinear functional relationships, using only observed plant input/output data, is a very appealing concept. Humans perform this type of task every day, learning to stabilize and control complex systems in a robust fashion. We use little a priori knowledge about the process, and built up models which can generalize and extrapolate locally to unforeseen states. Learning is both hierarchical and local. Currently researchers are trying to endow artificial neural networks with these behaviors, although there is still much research which needs to be performed before computers can even come close to rivaling the skills of humans in these areas. [1]

There are two models for fuzzy-neural controller. For an easy understanding it will start from the blocks of fuzzy controller (Figure 1a). The first model of fuzzy-neural controller is obtained keeping the fuzzification block and replacing the rule base, inference engine and defuzzification blocks with an artificial neural network. The second model is obtained replacing the fuzzification block with an artificial neural network and keeping the others three blocks. [2]

In this paper is used the first model for the fuzzy-neural controller which is implemented using an Associative Memory Network (AMN) type like is B-spline network (Figure 1b).



a b

Figure 1 (a) Block diagram of a fuzzy controller [2, 4]; (b) Schematic illustration of the B-spline type network [1]

From a fuzzy viewpoint, the univariate B-spline basis function represent fuzzy linguistic statements, such as "the error is positive small", and multivariate fuzzy sets are formed using the product operator to represent fuzzy conjunction. This link enables the B-spline network to be interpreted as a set of fuzzy rules and allows modeling and convergence results to be derived for the fuzzy network. These networks therefore embody both a qualitative and a quantitative approach, enabling heuristic information to be incorporated and inferred from neural nets, and allowing fuzzy learning rules to be derived, for which convergence results can be proved.

The output of the B-spline network is formed from a linear combination of a set of basis functions, which are defined on the *n*-dimensional input space. Since the support of the basis functions is bounded, only a small number of weights are involved in the network output calculation and the B-spline network stores and learn information locally.

B-spline AMNs adjust their weight vector, generally using instantaneous Least Mean Squares (LMS) type algorithms, in order to realize a particular mapping, modifying the strength with which a particular basis function contributes to the network output. The network's sparse internal representation simplifies the learning process as only a small percentage of the total weights contribute to the output and only these parameters are modified by the LMS rules. [1]

2 THE ALCS: EXPERIMENTAL STAND AND BLOCK DIAGRAM

In Figure 2 is presented the experimental stand.

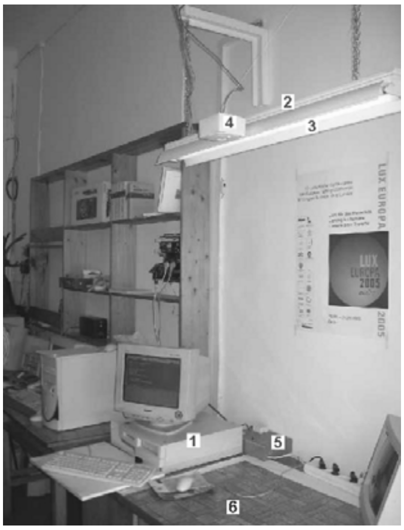


Figure 2 The experimental stand [3]

The experimental stand is composed of: (1) calculation equipment (PC IBM compatible, PIII, 433MHz, 64Mb RAM), (2) execution element (accomplished with two modules produced by Tridonic company: DSI-A/D converter, digital ballast PCA 2/36 EXCEL) introduced in the lighting body, (3) the technological installation based on two 36W fluorescent lamps, (4) light sensor (multifunctional LRI 8133/10 sensor produced by Phillips), (5) data acquisition board with two 8-bits conversion channels (an A/D channel, a D/A channel), (6) working plane.

In Figure 3 a is presented the block diagram of the ALCS where, are denoted with: $E_{desired}$ – the desired illuminance on the working plane; $E_{measured}$ – the measured illuminance on working plane; E_{real} – the illuminance on the working plane; $E_{daylight}$ – the daylight illuminance on working plane; $E_{electric}$ – the illuminance on working plane due to electric light; ε - control error; $\Delta\varepsilon$ - change in control error; U – control action (command); GE – scaling gain for the ε input of controller; GCE - scaling gain for the $\Delta\varepsilon$ input of controller; GU - scaling gain for the output of controller (change in command ΔU). In Figure 3b is presented the experimental model of the process. This model represents a LUT of measured data at the input and the output of process during night condition. The transformation given by the LUT is not single-valued, so the inverse model obtained by using the LUT is a gross approximation of the real inverse model of process.

The meaning of abbreviation *d8bv*, used in Figure 3 b, is "digital 8 bits value". The value 100 lx_{d8bv} represents the equivalent value obtained by conversion with A/D converter of the 500 lx, which represents the illuminance on working plane measured by an analog luxmeter. The value 127 V_{d8bv} represents, by conversion with D/A converter, the equivalent for a d.c. voltage with value 5 V_{dc}.

The fuzzy-neural controller is implemented as incremental type [2, 5] using BorlandC++ programming environment. The controller, based on the values of ε (control error – the difference between $E_{desired}$ and $E_{measured}$) and $\Delta\varepsilon$ (change in control error - the difference between current control error and anterior control error) will generate the change in control action denoted by ΔU. The control action U (where $U(kT)=U(kT-T)+\Delta U(kT)/GU$) will be applied to the process, in the purpose to maintain the illuminance in working plane close to the desired illuminance $E_{desired}$. T represents the sampling time. For the studies from this paper the desired illuminance has the value $E_{desired}$ = 100 lx_{d8bv}.

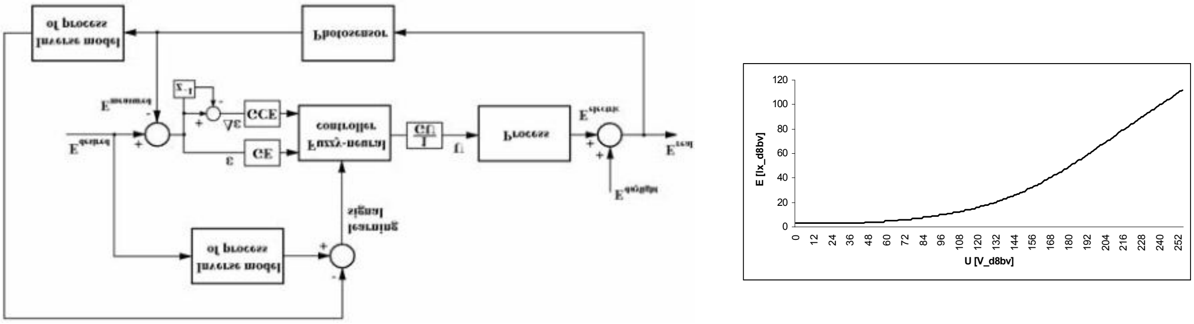


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Figure 3 (a) Block diagram of the ALCS; (b) The experimental direct model of process

3 EXPERIMENTAL RESULTS

The controller was implemented with a B-spline like network. The basis B-spline functions was replaced by Gaussian type basis function (Figure 4) given by [1]

$$a(x)=\begin{cases} \exp\left(-\dfrac{(\lambda_2-\lambda_1)^2/4}{(x-\lambda_1)(\lambda_2-x)}\right) & \text{if } x\in(\lambda_1;\lambda_2) \\ 0 & \text{otherwise} \end{cases}, \tag{1}$$

where (λ_1; λ_2) represents the support of basis function.

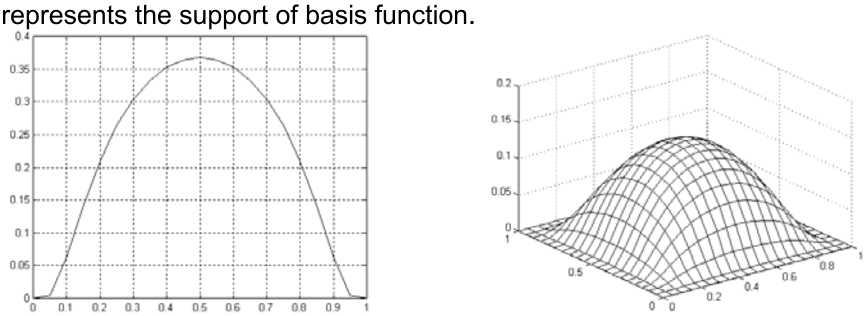

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Figure 4 Gaussian functions: (a) univariate Gaussian basis function; (b) two-dimensional multivariate basis function formed by taking the product of two univariate Gaussian basis functions [3]

The weight vector is adapted using the instantaneous normalized gradient descent rule [1] given by

$$\underline{\omega}(kT)=\underline{\omega}(kT-T)+\gamma\cdot\left(\frac{\Delta U_d(kT)-\Delta U(kT)}{\|\underline{a}(kT)\|_2^2}\right)\cdot\underline{a}(kT), \tag{2}$$

where are denoted by: γ the learning rate, $\underline{\omega}(kT)$ and $\underline{\omega}(kT-T)$ the weight vector at the moments kT and $(k-1)T$, $\Delta U_d(kT)$ and $\Delta U(kT)$ the desired respectively the calculated (by the B-spline network) change in command at the moment kT, $\underline{a}(kT)$ the active multivariate basis functions output vector at the moment kT.

When the fuzzy-neural network is initially designed, it is necessary to specify the number of intervals in which is divided each universe of discourse of each input. The support of a basis function is formed by two adjacent intervals. The basis functions are overlapped at 50% (Figure 5 a). The universe of discourse of the inputs of controller was restricted to the interval [-255; 255] lx_{d8bv} due to the 8 bits A/D converter. For short description it we denote by N_a the number of univariate basis functions displaced on the universe of discourse of the each controller input variable. In this paper, the number of the basis functions attached to each input of the controller was considered equal. Due to this setting, the number of two-dimensional multivariate basis functions on the two-dimensional input space of controller will be N_a^2 (Figure 5 b). The universe of discourse of the command, U, is restricted to the interval [0; 255] V_{d8bv} due to the 8 bits D/A converter.

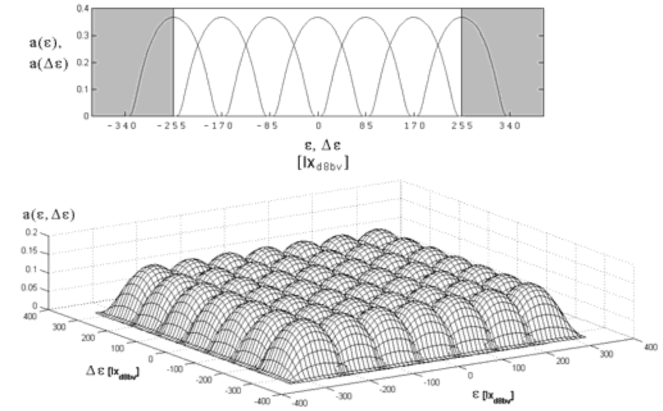

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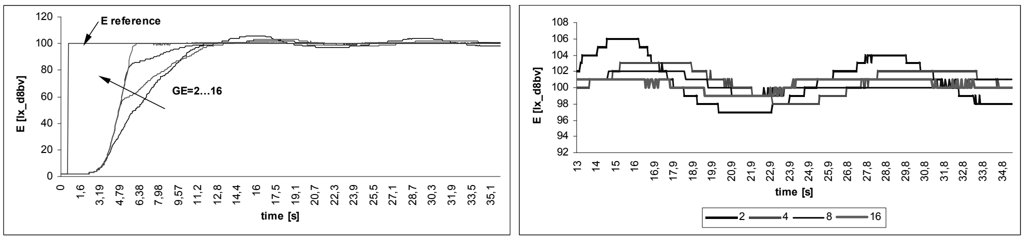
Figure 5 (a) Displacement of N_a=7 univariate basis functions on the universe of discourse of each input variable; (b) Displacement of N_a^2=49 two-dimensional multivariate basis functions on the two-dimensional input space (formed by the ε and $\Delta\varepsilon$) of fuzzy-controller

For tuning the controller, via universe of discourse of the input/output variables, the scaling gains *GE*, *GCE*, *GU* was used [5, 6]. For selecting the proper values of scaling gains, the step reference response of ALCS was used. The step reference response represents the response of the ALCS when the desired illuminance has the form of a step signal (the daylight is not present). For the studies from this paper the step signal has: 2 lx_{d8bv} (minimum illuminance produced by the lighting process) for the inferior value and 100 lx_{d8bv} for superior value. The step reference response of the ALCS offers useful information about the transient-state, steady-state and the stability of the ALCS.

In Figure 6 is presented a family of step reference responses of ALCS, for different values of scaling gain *GE*. The scaling gains *GCE* and *GU* are constant and equal with the value 16 and N_a=11. For all situations the steady-state behavior of the ALCS is characterized by not damped oscillations. As the *GE* increase as the amplitude of oscillations decrease. The necessary time, to meet the 100 lx_{d8bv} reference illuminance, starting from 2 l x_{d8bv} will decrease as the *GE* increase. Analyzing the step reference response family of ALCS from Figure 6 the better choice of scaling values of scaling gains is *GCE*=*GE*=16 *GU*=*GCE*=16, when N_a=11 univariate basis functions on each universe of discourse of the input variables of controller.



a b

Figure 6 (a) ALCS step reference responses family (*T*=55 ms, *GE*=variable, *GCE*=16, *GU*=16, N_a = 11); (b) detail from (a)

As in the case of Figure 6, the same studies about the relations between the scaling gains, was made for different values of N_a. After these studies, experimentally was determined the following proportions between the values of scaling gains, considering different values for N_a: N_a=11, *GCE=GE, GU*=*GCE*; N_a=9, *GCE=GE, GU*=1,5·*GCE*; N_a=7, *GCE=GE, GU*=1.875·*GCE*; N_a=5, *GCE=GE, GU*=2.45·*GCE*. Modifying the scaling gains, keeping the proportions between scaling gains presented above, a set of families of ALCS step reference responses it was acquired (Figure 7). Increasing the scaling gains will imply a decrease of the overshoot, a decrease of the amplitude of the steady-state control error oscillations but an increase of the transient response duration. Analyzing Figure 7 the authors recommend the use of the scaling gains, keeping the proportions between scaling gains presented above, with big values starting from *GE*=8.

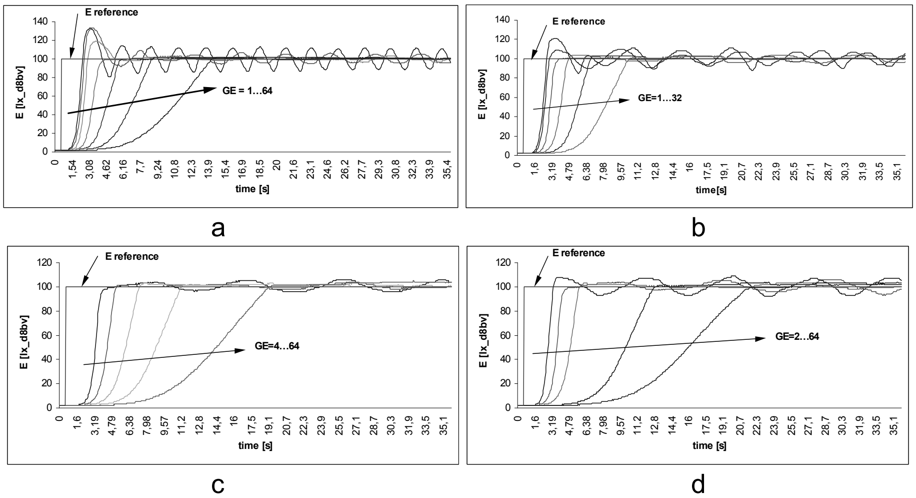


Figure 7 ALCS step reference responses families (T=55 ms): (a) GE=GCE=GU, N_a=11; (b) GU=1.5$\cdot GCE$, GCE=GE, N_a=9; (c) GU=1.875$\cdot GCE$, GCE=GE, N_a=7; (d) GU=2.45$\cdot GCE$, GCE=GE, N_a=5

In Figure 8 is depicted the behavior of the ALCS where the daylight illuminance is characterized by slowly changes. The steady-state error is in the interval [-2; 1] lx_{d8bv}, these values are not perceived by the human user. As it can see in Figure 8 c, the ALCS is stable. The illuminance on working plane was perturbed by the authors by: uncover rapidly a part of the covered widow; cover backwards rapidly the part of window uncovered. In both situations, the ALCS meet the desired illuminance on working plane.

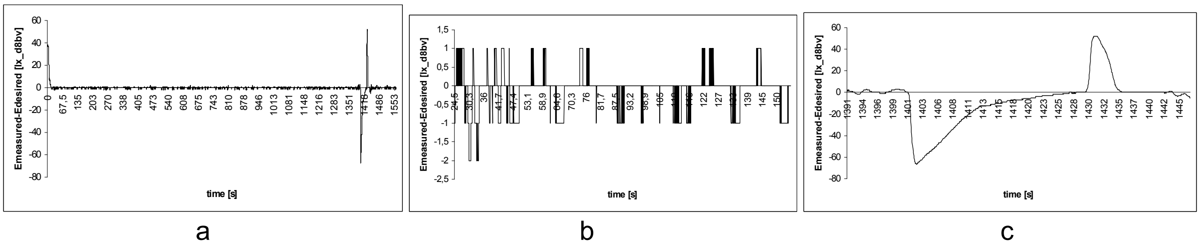


Figure 8 The behavior of ALCS (T=55 ms, GE=GCE=GU=16, N_a=11, daylight illuminance changes very slowly): (a) control error trajectory; (b) and (c) details of control error trajectory

In Figure 9 is presented the behavior of the ALCS where the daylight illuminance is characterized by rapidly changes. For example, it was acquired a variation of daylight illuminace: 21.9 lx_{d8bv}/s (Figure 9 f).

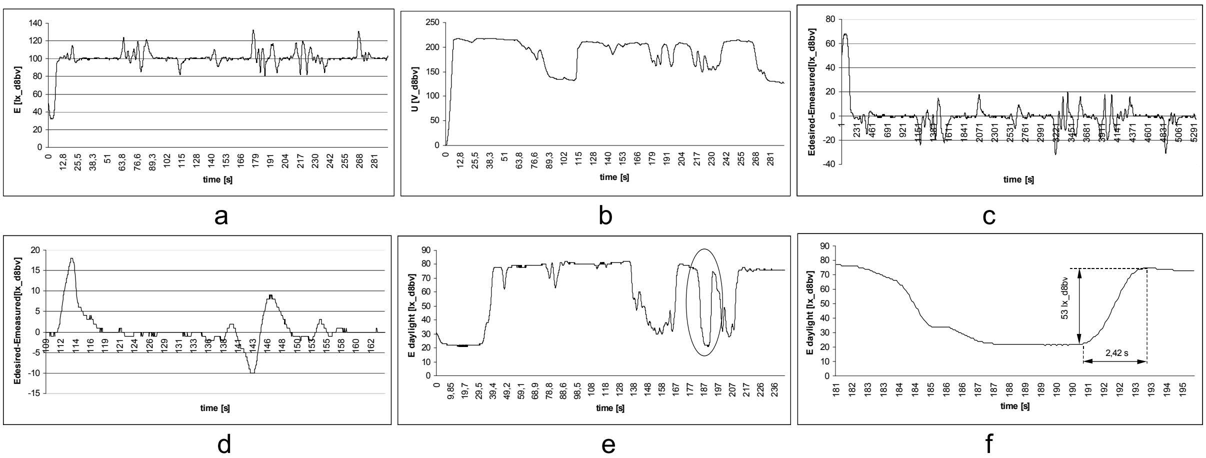


Figure 9 The behavior of ALCS (T=55 ms, GE=GCE=GU=16, N_a=11, daylight illuminance changes rapidly): (a) measured illuminance trajectory ; (b) command trajectory; (c) control error trajectory; (d) detail of control error trajectory; (e) daylight illuminance behavior; (f) detail from figure (e) - the sector surrounded by the ellipse

In the case of Figure 9, the variation of illuminance from working plane, due to daylight variation, is perceived by the human user but, will not bring visual discomfort for the human user. This variation is perceived like a gradually changes of the color of light. When the daylight decreases the color will change gradually from the daylight color to the color of the fluorescent lamps light. When the daylight increases the color will change gradually from the color of the fluorescent lamps light to the daylight color.

4 CONCLUSIONS

Starting from little a priori knowledge about the lighting process, the experimental model of the process, a control structure based on a fuzzy-neural controller was designed and implemented. For tuning the controller, the modification of universes of discourse of the input and the output variables of controller were selected. The modification of a universe of discourse of a variable is achieved by using a scaling gain. The study, respecting the influences of the scaling gains, was achieved by the analysis of the acquired step reference responses of the ALCS. The acquiring of the step reference response of ALCS allow the designer to find a proper proportion between the scaling gains as the ALCS will satisfies the imposed performances. The empirical tuning way used in this paper offers to the designer the possibility to set, in a logical manner, a fuzzy-neural controller as the ALCS satisfies he desired performances. The ALCS will have a good behavior even the changes of daylight illuminance are rapidly. The variation of daylight will be perceived by a gradually changes of color light due to the differences between the electric light and daylight colors, which will not bring a visual discomfort for the human user.

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FLUORESCENT DAYLIGHT CONTROL SYSTEM BASED ON NEURAL CONTROLLER

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ABSTRACT

The paper describes the design, implementation and tuning of a neural controller used in an automatic daylight control system. The automatic lighting control system (ALCS) attempts to maintain constant the illuminance at the desired level on working plane even if the daylight contribution is variable. Therefore, daylight will represent the perturbation signal for the ALCS. The mathematical model of this process is unknown. The applied control structure needs the inverse model of the process. An experimental model of process, a look up table (LUT) of measured data at the input and the output of process, was used. The transformation given by the LUT is not single-valued, so this inverse model obtained by LUT is a gross approximation of the actual inverse model of process. Even if the inverse model of process is not the best solution, a set of settings was obtained for a neural controller like ALCS satisfies the imposed performances.

1 INTRODUCTION

The interest in artificial neural networks (ANNs) increased when the limitation of the types of logical functions a single perceptron could reproduce became apparent. During the sixties became well known that multi-layer networks were capable of reproducing these mappings, but no learning algorithm capable of training these more complex structures existed. Even when the back-propagation (BP) training rule was reinvented in the mid-eighties, it was doubtful whether it would have been useful during the sixties, due to limited computing power available at that time. The BP algorithm is a gradient descent algorithm, which become very popular because of its efficient way for calculating the network's sensitivity derivatives. Multi layer perceptron (MLP) networks are composed of perceptron "type" units or nodes, which are arranged into layers where the outputs of the nodes in one layer constitute the inputs to the nodes in the next layer. The signals received by the first layer are the training inputs and the network's response is the outputs of the last layer (Figure 1 a). Each of the nodes has associated with it a weight vector and a transfer (or activation) function (denoted by *F*), where the dot product of the weight vector and the incoming input vector is taken, and the resultant scalar is transformed by the activation function (Figure 1 b). For a suitable arrangement of nodes and layers, and for appropriate weight vectors and activation functions, it can be shown that this class of networks can reproduce any logical function exactly and can approximate any continuous nonlinear function to within an arbitrary accuracy. [1]

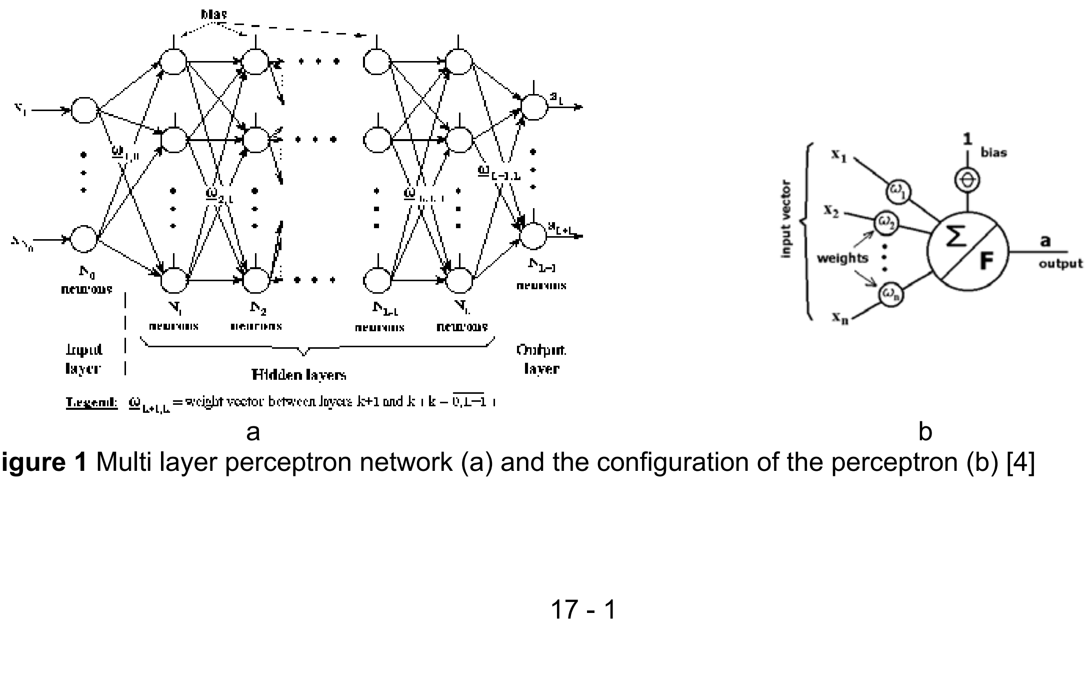


Figure 1 Multi layer perceptron network (a) and the configuration of the perceptron (b) [4]

2 THE ALCS: EXPERIMENTAL STAND AND BLOCK DIAGRAM

Figure 2 presents the experimental stand.

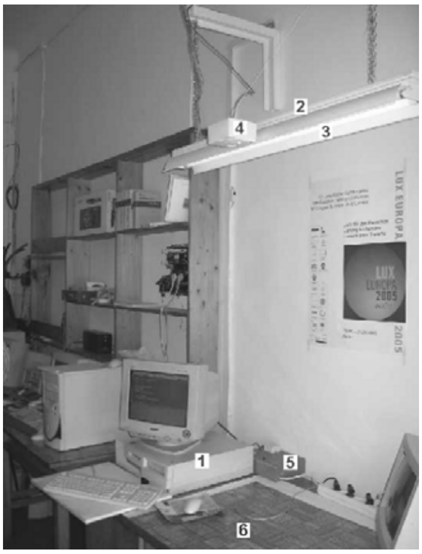


Figure 2 The experimental stand [3]

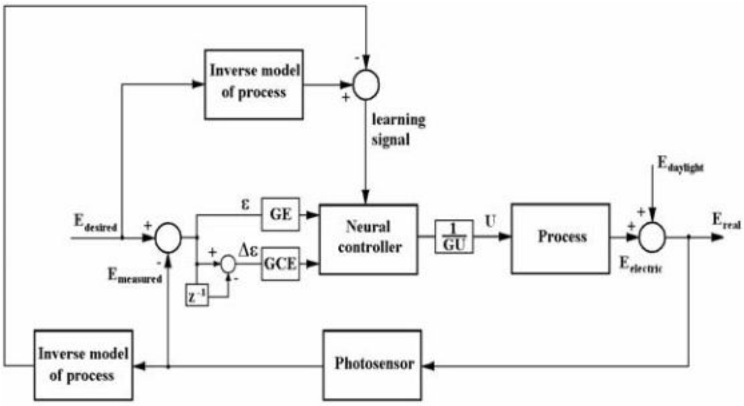


Figure 3 Block diagram of the ALCS

The experimental stand is composed of: (1) calculation equipment (PC IBM compatible, PIII, 433 MHz, 64 Mb RAM), (2) execution element (accomplished with two modules produced by Tridonic company: DSI-A/D converter, digital ballast PCA 2/36 EXCEL) introduced in the lighting body, (3) the technological installation based on two 36 W fluorescent lamps, (4) light sensor (multifunctional LRI 8133/10 sensor produced by Phillips), (5) data acquisition board with two 8-bytes conversion channels (an A/D channel, a D/A channel), (6) working plane.

Figure 3 describes the block diagram of the ALCS where the following notations are made: $E_{desired}$ – the desired illuminance on the working plane; $E_{measured}$ – the measured illuminance on working plane; E_{real} – the illuminance on the working plane; $E_{daylight}$ – the daylight illuminance on working plane; $E_{electric}$ – the illuminance on working plane due to electric light; ε - control error; $\Delta\varepsilon$ - change in control error; U – control action (command); GE – scaling gain for the ε input of controller; GCE - scaling gain for the $\Delta\varepsilon$ input of controller; GU - scaling gain for the output of controller (change in command ΔU).

Figure 4 presents the experimental model of the process. This model represents a LUT of measured data at the input and the output of process during night condition. The transformation given by the LUT is not single-valued, so the inverse model obtained by using the LUT is a gross approximation of the real inverse model of process.

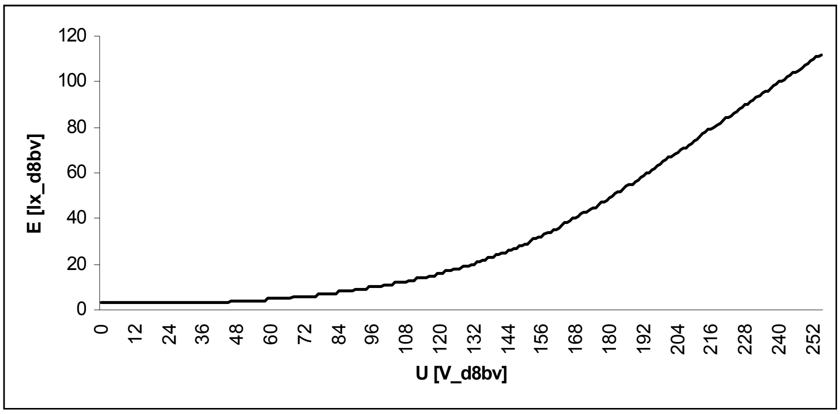


Figure 4 The experimental model of process

The meaning of abbreviation *d8bv*, used in Figure 4, is “digital 8 bits value”. The value 100 lx_{d8bv} represents the equivalent value obtained by conversion with A/D converter of the 500 lx, which represents the illuminance on working plane measured by an analog luxmeter. The value 127 V_{d8bv} represents, by conversion with D/A converter, the equivalent for a d.c. voltage with value 5 V_{dc}.

The neural controller is implemented as incremental type [2, 7]. The controller, based on the values of ε (control error – the difference between $E_{desired}$ and $E_{measured}$) and $\Delta\varepsilon$ (change in control error - the difference between current control error and anterior control error) will generate the change in control action denoted by ΔU. The control action U (where $U(kT)=U(kT-T)+\Delta U(kT)/GU$) will be applied to the process, in the purpose to maintain the illuminance in working plane close to the desired illuminance $E_{desired}$. T represents the sampling time. For the studies from this paper the desired illuminance has the value $E_{desired}$=100 lx_{d8bv}.

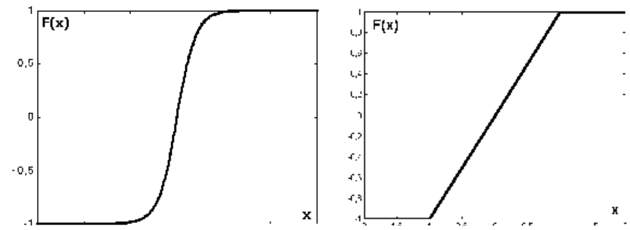
3 EXPERIMENTAL RESULTS

The controller was implemented with an ANN with three layers (input layer, hidden layer, output layer). The input layer has two neurons, the hidden layer has six neurons and the output layer has one neuron. The activation function, for the neurons from hidden layer, is the bipolar sigmoid function (Figure 5 a) given by

$$F(x)=\frac{1-e^{-2x}}{1+e^{-2x}} \qquad (1)$$

and, for the neuron from the output layer is the linear function with limitation (Figure 5 b) given by

$$F(x)=\begin{cases} -1, & x\le -1 \\ x, & -1<x<1\,. \\ 1, & x\ge 1 \end{cases} \qquad (2)$$



a b

Figure 5 Activation functions:
(a) bipolar sigmoid; (b) linear with limitation

The ANN is trained on-line using the back-propagation training rule.

The universes of discourse of the inputs (ε, $\Delta\varepsilon$) and output (ΔU) variables of the controller was fixed to the interval of integers [-(2^8-1); +(2^8-1)]=[-255; 255], due to the 8 bits A/D and D/A converters. The inputs and the output of ANN are scaled [5]. The universes of discourse of the ε, $\Delta\varepsilon$ variables are converted in the intervals [-1; 1]. Due to the linear with limitation activation function of the neuron from the output layer, the output of the ANN has values in the interval [-1; 1]. These values are converted in values in the interval [-255; 255], which represents the universe of discourse of the ΔU variable of neural controller. Finally, the command, U, will has a value in the interval [0; 255] V_{d8bv}. For tuning the controller, via universe of discourse of the input/output variables, the scaling gains *GE*, *GCE*, *GU* was used [6, 7].

Figure 6 gives families of step reference responses for different values of scaling gains *GE* and *GCE*. For all situations the steady-state behavior of the ALCS is characterized by not damped oscillations.

The step reference response represents the response of the ALCS when the desired illuminance has the form of a step signal. For the studies from this paper the step signal has: 2 lx_{d8bv} (minimum illuminance produced by the lighting process) for the inferior value and 100 lx_{d8bv} for superior value. The step reference response of the ALCS offers useful information about the transient-state, steady-state and the stability of the ALCS.

In Figure 6.a we may see a minor decrease of amplitude of oscillations as *GE* decreases. A bigger influence in modifications of oscillations amplitude may be seen in Figure 6.b, where the amplitude of oscillations will increase as the *GCE* increase. A family of ALCS step reference responses for *GU* variable it is not necessary because the influence of increasing *GU* is evident. An increase of *GU* will imply a change of command, *U*, with a smaller amount $\Delta U/GU$ for the same ΔU.

Figure 7 depicts the step reference responses family of ALCS for different values of learning rate, denoted by γ. Figure 8 presents a detailed fragment of Figure 7.

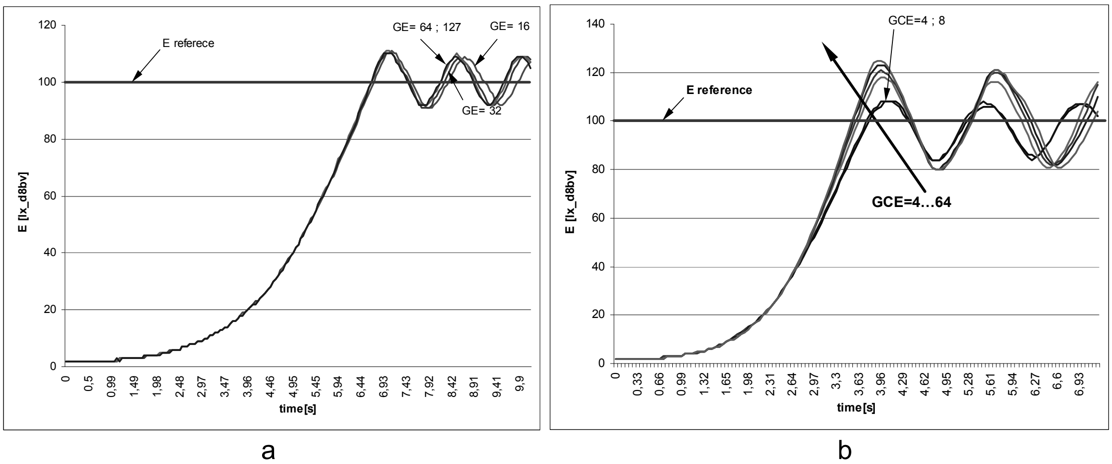


Figure 6 Families of ALCS step reference responses of ALCS (T=55 ms):
(a) GE=variable, GCE=127, GU=127; (b) GE=1, GCE=variable, GU=64

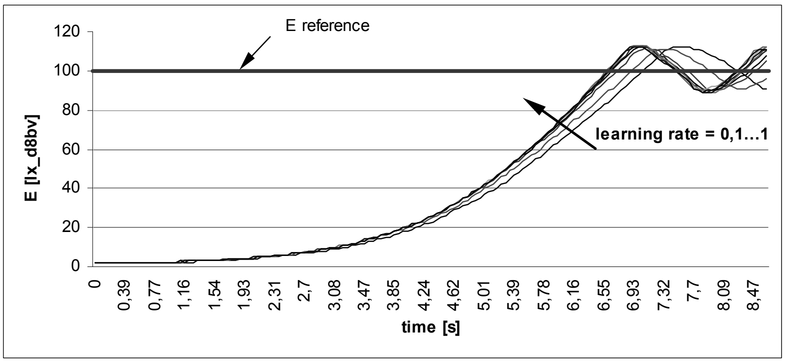


Figure 7 Family of ALCS step reference responses (T=55 ms):
learning rate is variable (γ=0.1…1, increment step set to 0.1)

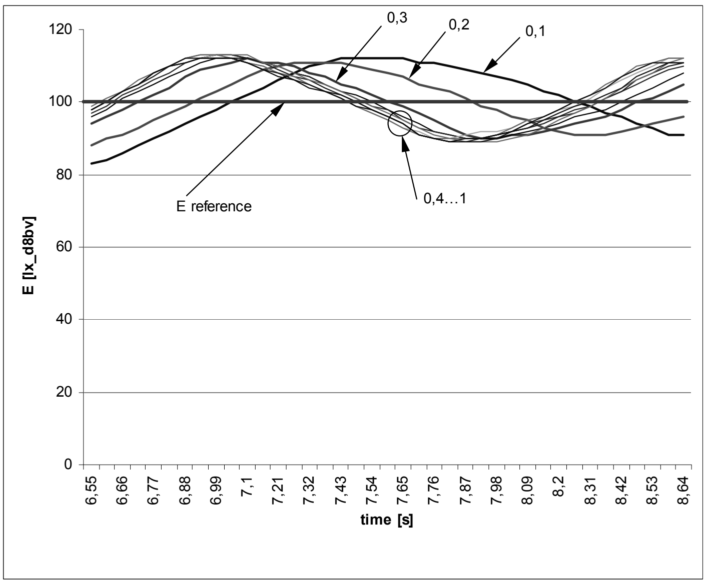
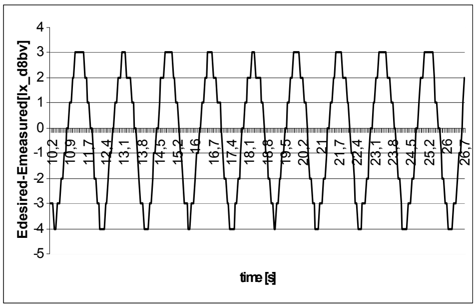


Figure 8 Family of ALCS step reference responses: detail from Figure 7

Figure 9 describes the influences of the sampling time. As the sampling time increases, the amplitude of the steady-state control error oscillations decreases.



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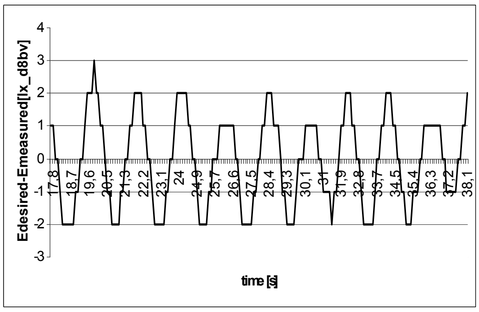

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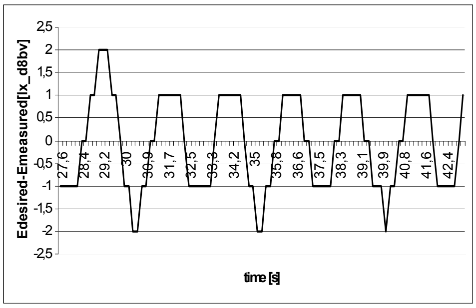


c

Figure 9 ALCS steady-state behavior for different values of sampling time: (a) T=55 ms; (b) T=110 ms; (c) T=165 ms

For reducing the amplitude of oscillations, during the steady-state, two ways was selected. The first way imply the using of small values for scaling gains (GE=1, GCE=8, GU=16), learning rate γ=0.98, sampling time set to 55 ms and turn off the training of ANN when the learning error is smaller, for example, like value 0.99 (Figure 10). The second way imply the using of big values for scaling gains (GE=16, GCE=64, GU=256), learning rate γ=0.3, a bigger sampling time (165 ms) and never turn off the training of ANN (Figures 11 and 12).

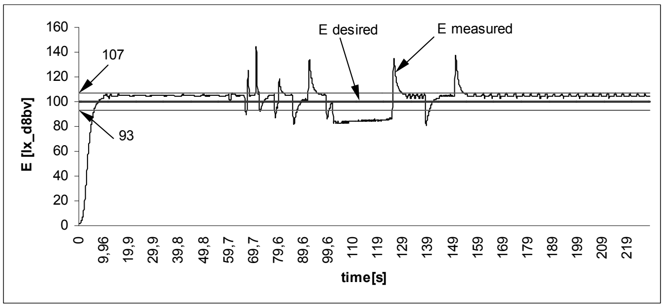
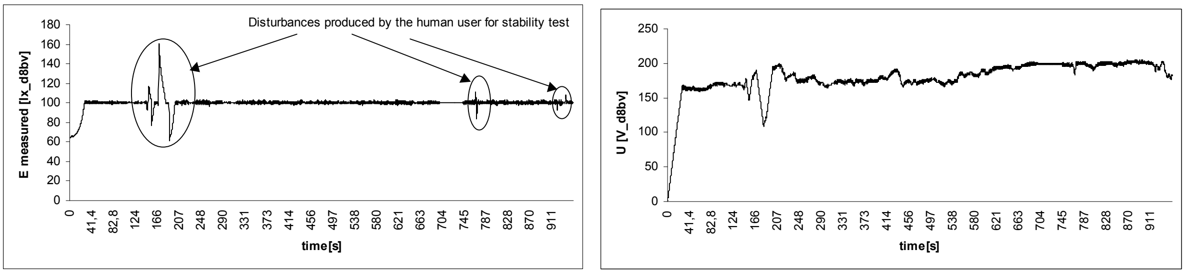


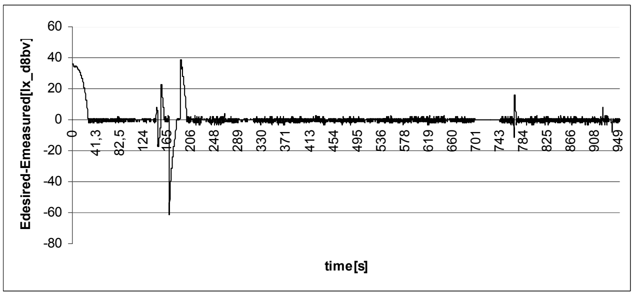
Figure 10 Behavior of ALCS (T=55 ms, GE=1, GCE=8, GU=16, γ=0.98). The training of ANN is turn off when the learning error is smaller like 0.99

As we may notice in Figure 10, the measured illuminance has values around the desired illuminance ($E_{desired}$=100 lx_{d8bv}), in the interval [100; 107] lx_{d8bv} (experimentally, a variation of measured illuminance in the interval [93; 107] lx_{d8bv} was not perceived by the human user). The experimental data was acquired by the night conditions. The stability of ALCS was tested by perturbing the illuminance on working plane by rapidly changing the reflecting surface of the working plane. The weak of this way, is the weak training of the ANN. For example between the 100 and 120 seconds of the horizontal axe, the measured illuminance has values smaller like 93 lx_{d8bv}, even the learning error is smaller 0.99. To solve this problem, the training of ANN when the absolute control error has value bigger like 7 lx_{d8bv} must turned on.

Figure 11 presents the behavior of ALCS (measured illuminance, command and control error trajectories) when the scaling gains have big values (GE=16, GCE=64, GU=256), the sampling time is set to T=165 ms and the ANN is trained every time sample. Figure 12 presents details of the control error trajectory depicted in Figure 11.c. The experimental data was acquired by the day conditions in the presence of the human users. Figure 11.a depicts the trajectory of the measured illuminance in working plane. In the sectors of the trajectory surrounded by ellipses it was tested the stability of the ALCS by uncovering and covering rapidly a part of the windows of the office where is placed the experimental stand. In order to do this test of stability, first cover a portion of the window of office, turn on the ALCS and wait the ALCS meet the steady-state; second, uncover rapidly a part of the covered widow and wait the ALCS meet the steady-state; third, cover backwards rapidly the part of window uncovered in the second step and wait the ALCS meet the steady-state. As we may see in Figures 11 a, 11 c and 12 c, the ALCS is stable.

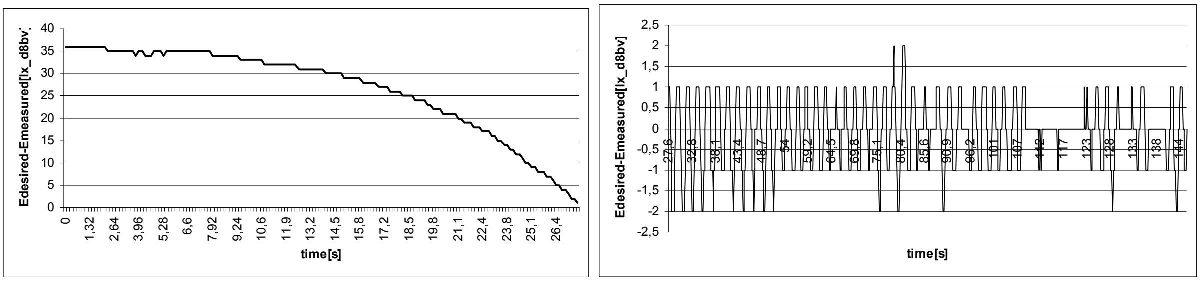


a b



c

Figure 11 Behavior of ALCS (*T*=165 ms, *GE*=16, *GCE*=64, *GU*=256, γ=0.3, ANN trained all the time):
(a) measured illuminance trajectory;
(b) command trajectory;
(c) control error trajectory



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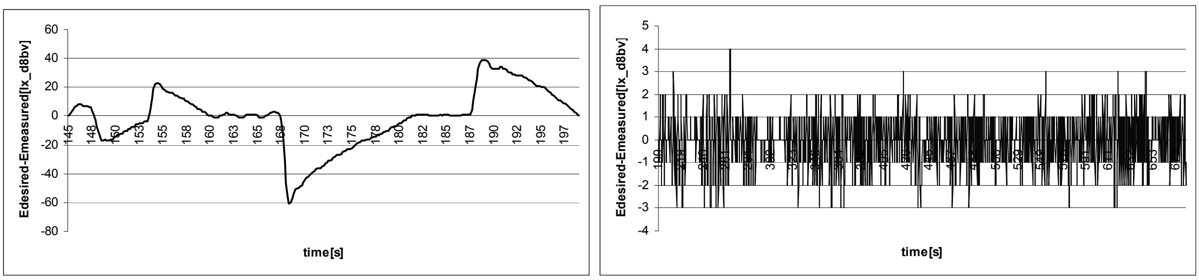

c d

Figure 12 Details of control error trajectory from Figure 11 c, time intervals:
(a) [0; 27.555] s; (b) [27.555; 145.365] s; (c) [145.365; 198.825] s; (d) [198.825; 682,605] s

Analyzing the graphics from Figures 12 a and 12 c, we may notice when the ALCS starts first time, its response to meet the desired value of illuminance is slow (the start error control is 36 lx_{d8bv}). For this situation the transient time is about 27 seconds. At the start time the ANN is not trained. Because of the training of ANN when is created, again, a similar condition for ALCS respecting the value of control error, the transient time will be smaller. For example in Figure 12 c, at 189 seconds, a perturbation of the illuminance in working plane for stability test is produced. The error control has the maximum value of 39 lx_{d8bv}. The transient time, time for illuminance in working plane to reach the desired 100 lx_{d8bv} illuminance, has the value 9.825 seconds.

Analyzing the graphics from Figures 12 b and 12 d, the steady-state error control has values in the interval [-3; 4] lx_{d8bv}. The extreme values of the intervals are rarely met. The majority values for error control are in the interval [-2; 1] lx_{d8bv}. From the human eye perception, the human user of the ALCS does not perceive these oscillations.

4 CONCLUSIONS

The proposed structure, used to control the lighting process, need an inverse model of the process. The mathematical model of the process is unknown. To solve the problem, an experimental model of process was used. The experimental model is in the form of a LUT of measured data at the input and the output of the lighting process. The LUT is obtained by measuring the process output data for the all-possible process input data (direct model of process). This experimental model offers a not single-valued transformation of the process input data in the process output data. This implies an approximate inverse model of the process (a transformation of the process output data in the process input data). Even if the inverse model of process is not the best solution a set of settings, for neural controller as ALCS satisfies the imposed performances, was obtained.

For the tuning the neural controller is proposed the tuning via the universe of discourse of the input and output variables of the controller. In [3], for this type of tuning, the domains of the possible values of the input and output variables were modified. In this paper, the universe of discourse is changed by using scaling gains (a convenient way) for the inputs and output of controller keeping the domains of the possible values of the input and output variables constant. The influences of the scaling gains are studied using the step reference responses of ALCS. The tuning process of the controller is completed by supplementary studying the step reference responses of ALCS respecting the influences of the learning rate and the sampling time.

Finally, we may say that the classical tool (from automatic view) represented by the step reference response becomes a useful tool for tuning a neural controller. This tool offers to the designer the possibility to set, in a logical manner, a neural controller as the ALCS satisfies he desired performances. Using the step reference response of the ALCS the setting of the neural controller in a vague manner is avoided.

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THE LIGHTING DESIGN OF ARCHEOLOGICAL SITES: PAST AND FUTURE OF PIAZZA ARMERINA

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ABSTRACT

The Villa Romana del Casale is located about 5km outside the town of Piazza Armerina. It is the richest, largest and most complex collection of late Roman mosaics in the world. The Villa Romana del Casale is a UNESCO World Heritage Site.

The Villa Romana del Casale was constructed on the remains of an older villa in the first quarter of the fourth century, probably as the centre of a huge latifundium covering the entire surrounding area. How long the villa kept this role is not known.

The existence of the villa was almost entirely forgotten (some of the tallest parts have always been above ground) and the area used for cultivation. Pieces of mosaics and some columns were found early in the 19th century, and some excavations were carried out later in that century, but the first serious excavations were performed in 1929 and later in 1935-39. The latest major excavations were in the period 1950-60, after which the current cover was build. Currently only the manorial parts of the complex have been excavated. The ancillary structures, housing for the slaves, workshops, stables etc, have not yet been located.

Actually, a completely new project of the Villa has been carried out, thanks to the contribution of the European Community. The preliminary phase of the design is now completed: a lot of problems associated to the previous design, specifically from the artificial and daylight light points of view, have been solved, and it is possible to give an idea of what will be the luminous environment inside the rooms, during the day, especially considering the structure foreseen for the new project.

The aim of the paper is to present the contrast between the actual situation and the new solutions, adopted for creating the proper lighting environment for a good fruition of the site in a very special environment like the one considered, where mosaics and ancient environments should result in a perfect mix of history and art.

1 INTRODUCTION

In situ conservation of archaeological goods is indoubtly a very interesting alternative to the traditional conservation of single elements in museums. By this way, it is possible in give them a role and a meaning inside the site, in relation to the spaces and the environments they belong to, leaving to the visitors the possibility of a complete and immediate fruition, and a more involving approach to the site.
Artificial lighting systems have a very important but delicate role, as they could influence the interpretation of the site, help the comprehension of the places, and could recall ancient atmospheres, going beyond their use only as an economic instrument destined to extend to the night the possibility to visit the site, or/and for shows and performances. Apart from its economic and cultural importance, this kind of approach requires the use of systems, materials and techniques that should be at the same time consistent with the two generally opposite needs of fruition and conservation. For the lighting equipment in particular several aspects should be considered, such as presence, maintenance, management, supply and distribution, influence on the local microclimate.

The present paper has the goal to identify the most influencing aspects that should be considered in the natural and artificial lighting design of archaeological sites. It is developed considering the case study of the *Design for Recovery and Conservation of the Villa Romana del Casale,* an Italian archaeological site placed in Sicily.

A multidisciplinary team managed by the Centro Regionale per la Progettazione e il Restauro della Regione Sicilia (*CRPR*), directed by the Arch. Guido Meli, has developed the *Design* following the guidelines defined by the responsible of the site, On. Vittorio Sgarbi. In particular, the Department of Fisica Tecnica of the University of Rome "La Sapienza" has been involved in the environmental analysis of the actual situation from the visual and thermal points of view.

2 THE *VILLA DEL CASALE* ARCHAEOLOGICAL SITE

The *Villa del Casale* is a late Roman construction probably belonging to the 285-305 DC period, located about 5km outside the town of Piazza Armerina. It was damaged, maybe destroyed during the domination of the Vandals and the Visigoths, but the buildings remained in use, at least in part, during the Byzantine and Arab period. The site was finally abandoned for good when a landslide covered the villa in the 12th century, and remaining inhabitants moved to the current location of Piazza Armerina. The size of the villa and the amount and quality of the artwork indicate that the villa was the main centre of such a latifundium, whose owner was probably a member of senatorial class if not of the imperial family itself, i.e., the absolute upper class of the Roman Empire. It is the richest, largest and most complex collection of late Roman mosaics in the world, and it is a UNESCO World Heritage Site. It's extension is up to 3500 m^2 (Figure 1).

The whole complex is organised along three major axes. The primary axis is the (slightly bend) line that passes from the atrium, tablinum, peristyle and the great basilica (coinciding with the path visitors would follow), while the thermal baths and the elliptical peristyle with the triclinium are centred on separate axes. In spite of the the different orientations of the various parts of the villa they all form a single structure, build at the same time. There are no indications that the villa should have been build in several stages. The villa was a single-story building, centred around the peristyle, around which almost all the main public and private rooms were organised. Entrance to the peristyle is via the atrium from the W., with the thermal baths to the NW., service rooms and probably guest rooms to the N., private apartments and a huge basilica to the E., and rooms of unknown purpose to the S. Somewhat detached, almost as an afterthought, is the separate area to the S. with the elliptical peristyle, service rooms and a huge triclinium. The overall plan of the villa was dictated by several factors: older constructions on the site, the slight slope on which it is build and the passage of the sun and the prevailing winds. The higher ground to the east is occupied by the Great Basilica, the private apartments and the Corridor of the Great Hunt, the middle ground by the Peristyle, guest rooms, the entrance area, the Elliptical Peristyle and the Triclinium, while the lower ground to the west is dedicated to the thermal baths.


Figure 1 A view of the site from an aeroplane and the map of the site available for a visitor.

Figure 2 A view of the transparent coverings

Actually, part of the site is protected by transparent coverings realised in metacrilate, and by transparent vertical surfaces, all designed by the Arch. Francesco Minissi in the sixties (Figure 2). The description of the luminous environment by Minissi sounds like this: "…*is assured the optimum of visibility of the pavements, lighted by the diffuse light filtering through the coverings…*"; more, "…*there is a soft light that does not create probles to the visitor…and it resists to the variations of temperature…*".

3 ENVIRONMENTAL PROBLEMS OF THE *VILLA DEL CASALE*

The approach followed by the architect Minissi was very impressive and of architectonical value, but based on the use of a material (*perspex*) that actually is not recommended for the fruition and conservation of archaeological sites, because of the microclimatic conditions caused by its solar and visual transmittances. They are the main responsible of the greenhouse effect produced inside the environments, generating indoor temperatures up to 50 °C in summer.

Beside the initial design choices, two other aspects contributed to the actual state of degradation: the alteration of the materials with time, and the changes introduced to the original design, especially the replacement of several vertical structures with glazing, that increased the greenhouse effect, and the closing towards the peristilium, that reduced the ventilation of the inner environments.

More, the old lighting system, composed of fluorescent lamps realising a quasi horizontal lighting, has been removed, because of its age, and because the supports were put on painted walls. The lighting system actually working is put at the top of the ceiling, and it is realised with 35 W linear tubes (T16, 4000 K) equipped with a antiglare shading, guaranteeing an average illuminance value up to 100-130 lx on the mosaic surfaces. This system is working during both the diurnal (when required) and nocturnal visits.

The actual luminous climate inside the site is well represented in the two following Figures 3 and 4, presenting the bad conditions during a diurnal visit and during a nocturnal visit. The problems are evident: greenhouse effect, shadings, glare due to direct radiation, reflected glare, disuniform illumination, bad conditions of chromaticity, inadequate understanding of architectural spaces, interference with the external illumination.

Figure 3 A diurnal visit: glare due to direct radiation, reflected glare, alteration of chromaticity.

Figure 4 A nocturnal visit: disuniform illumination, reflected glare, chromatic alterations.

4 LIGHTING DESIGN OF ARCHEOLOGICAL SITES: THE CASE STUDY OF THE *Villa del Casale*

Some few basic features should be considered in the lighting design of an archaeological site:

- Illuminance should be set counterbalancing the need for a visual delight and the need for a proper conservation of the mosaics;

- The uniformity of illuminance should bet set considering the reading that the designer wants to give of the mosaics: geometrical, generally repeated, elements (or damaged elements) could present a lower uniformity than painted scenes; on the other side, 3D objects require some uniformity to put in relief shape and architectural meaning of the painting;
- Chromatic aspects should be considered in order to assure the possibility of recognizing and distinguish at the best the different colours;
- Warm Colour Temperature (2500-3500 K) should be preferred to exalt the chromaticity of elements;
- Keep care of glare;
- The lighting of objects should prevail on the lighting of the environment, to catch the interest of the visitor;
- Other important aspects are: energy saving, minimum presence of the system, availability of materials, easy maintenance, safety.

The lighting solutions (referred to daylight as well as to artificial light) should assure some functions (Fig. 5):

- General illumination: should be designed for creating a global or partial illumination on the mosaics;
- Accent illumination: integrating the general illumination, fit for exalting specific elements of each environment, it should underline and put in light the key aspects characterising the archaeological site;
- Transit illumination: appositely fit for recognising the route;
- Safety and Emergency illuminations.

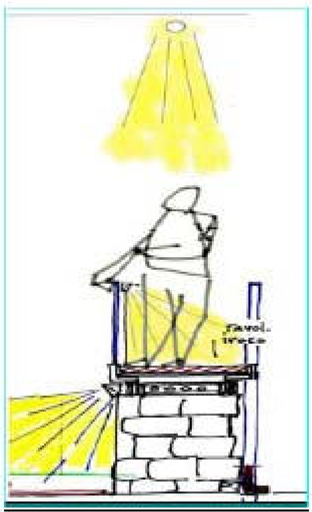

Figure 5 Artificial lighting solutions.

The new design, still at the conceptual step, is based on the recovery of Minissi's conceptual idea, although some differences could be noted:

- The coverings will be realised with an opaque and ventilated structure that should avoid the luminous and thermal interaction between the inner and the outer environments (Fig. 6); the same should be done for the vertical structures, apart from the external apertures, to assure the proper perception of the light/shade ratio;
- Two different kinds of visits will be proposed, a diurnal one and a nocturnal one; the first will be based on the illuminance provided by the natural sources of light, sun and sky, recreating the ancient atmosphere of the villa. The nocturnal visit will be based on accent and general illumination systems;
- External illumination will be based on low energy solutions, that should show the villa as it would be lighted by the moonlight, recreating an ancient atmosphere and reducing so far the luminous pollution.

A fundamental topic of the lighting design is the chromaticity of the mosaics. Actually, they are in a state of degradation due to the presence of Calcium and Sodium salts on their surfaces alterating their chromatic aspects, and they will be recovered through techniques that cannot assure the optimum results from a chromatic viewpoint. The great difference among all the mosaic surfaces, in terms of dimensions and characteristics (colour, reflectance, position, state of degradation and possible recovery) of the mosaics still increase the complexity of the lighting design.

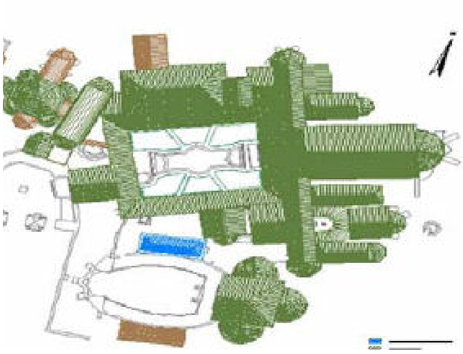

Figure 6 The new coverings of the villa.

This is the reason why the conceptual phase of the design has been based on an experimental approach, more than on the use of software simulations. While the natural light analysis was simplified by the decision of using opaque coverings and “original” vertical apertures, where present, several artificial lighting solutions has been tested and compared. A thorough analysis has been carrired out by measurements with a spectroradiometer (objective analyis) and by visual tests (subjective analysis) effectuated together with the main actors involved in the whole design of the site (archaeologists, architects, restorers). An example of the experimental approach is presented in Figure 7a, b. In the latter, it is presented for a surface the difference among the actual situation (first photograph) lighted with the new lighting solution, using a 75 W spheric iodide lamp, the situation in which the mosaic il lighted by natural light, and the foreseen final situation of recovery, obtained washing the surface.

From the tests, it results that the better conditions will be achieved with linear penta phosphor lamps for the general lighting, and with discharged iodide spherical lamps (with a high component in the red field) for the accent illumination. There have been used only one kind of spot and one kind of linear system, equipped then in different ways (filters and optics, assembly system) in relation to the characteristics of each environment considered, to counterbalance the need for good lighting and the future aspects of lighting management.

An example of simulations and renderings are instead presented in Figure 8.

Figure 7a, b An example of the experimental approach.

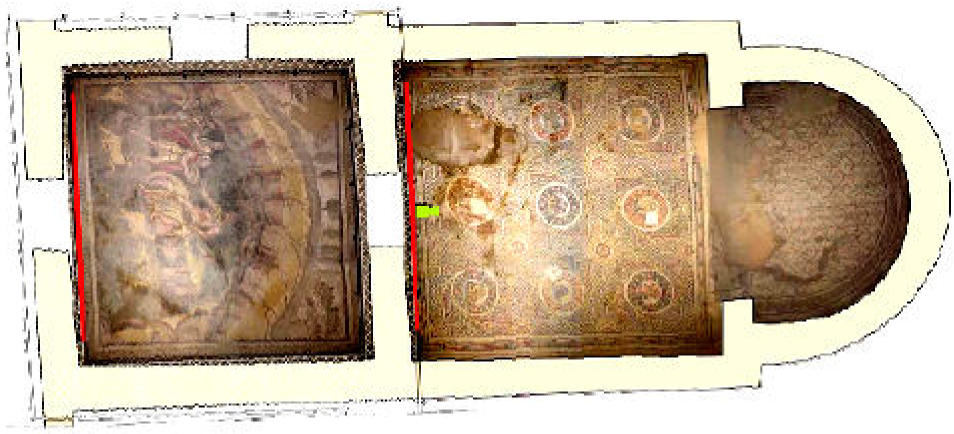

Figure 8 An example of a rendering of a room of the Villa.

4 CONCLUSIONS

The Villa Romana del Casale is a UNESCO World Heritage Site for the great collection of late Roman mosaics it collects. It was constructed in the first quarter of the fourth century, and after a series of excavations, it was organised to be an archaeological site open to visitors. An important work was done by Arch. Minissi in the 1960s.

Actually, a completely new project of the Villa has been carried out. The paper has shown the problems associated to the previous design, specifically from the artificial and daylight light points of view, and the way the designers followed to solve them, defining a sort of guide line for the first steps of a lighting design in archaeological sites like the one here considered, to create the proper lighting environment.

AKNOWLEDGEMENTS

We wish to thank the *CRPR* technical staff, and in particular its director, Arch. Meli, Arch. S. De Filippis for his useful suggestions and his active cooperation, Arch. L. Calcagnini for the enthusiasm and care, the *iGuzzini* lighting society, that helped us with materials and products for the experimental phase of the work.

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LIGHTING
– ENERGY CONSUMPTION AND ENERGY EFFICIENCY

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ABSTRACT

The IEA Annex 45 – Energy Efficient Electric Lighting for Buildings is an international co-operation project on energy-efficient lighting. Currently there are 20 participating and corresponding countries and 37 organisations in the project. The objectives of IEA Annex 45 are to identify and accelerate the use of energy-efficient high-quality lighting technologies and their integration with other building systems, to assess and document the technical performance of existing and future lighting technologies, as well as to assess and document the barriers preventing the adoption of energy-efficient technologies, and to propose means to resolve these barriers.

1 INTRODUCTION

International Energy Agency (IEA) is an intergovernmental body committed to advancing security of energy supply, economic growth and environmental sustainability through energy policy co-operation. IEA has Implementing Agreements (IA) to organize research. One of these IAs is Energy Conservation in Buildings and Community Systems (ECBCS). The function of ECBCS is to undertake research and provide an international focus for building energy efficiency. The tasks in ECBCS are undertaken through a series of Annexes that are directed at energy saving technologies and activities that support their application in practice. The results are also used in the formulation of energy conservation policies and standards.

The Executive Committee of the ECBCS program established a new Annex in June 2004 called Energy Efficient Electric Lighting for Buildings. Professor Liisa Halonen from Lighting Laboratory of Helsinki University of Technology was elected for the Operating Agent of the Annex 45.

2 LIGHTING ENERGY AND EFFICIENCY

Lighting is a large and rapidly growing source of energy demand and greenhouse gas emissions. In 2005 the energy consumption of grid-based electric lighting was 2 650 TWh worldwide, about 19 % of the total global electricity consumption. That means 133 petalumen-hours (Plmh) of electric light was used, an average of 21 megalumen-hours/person. However the use of this light is very unevenly ditributed. In addition 55 billion litres of gasoline and diesel are annually used to operate vehicle lights. More than one-quarter of world's population uses liquid fuel (kerosene) to provide lighting. [1] The global lighting electricity use is distributed approximately 28 % to the residential sector, 48 % to the service sector, 16 % to the industrial sector, and 8 % to street and other lighting. For the industrialized countries national lighting electricity use ranges from 5 % to 15 %, while in developing countries the value can be as high as 86 % of the total electricity use. [2]

More efficient use of electric lighting would limit the rate of electric power consumption increase, reduce the economic and social costs resulting from constructing new generating capacity, and reduce the emissions of greenhouse gases and other pollutants. At the moment fluorescent lamps dominate in office lighting. In domestic lighting the dominant light source is still the more than a century old, inefficient incandescent lamp. The aspects to consider in providing efficient lighting are energy savings, daylight use, individual control of light, quality of light, emissions during life cycle and total costs.

The building sector in the EU consumes over 40 % of energy use in EU and is responsible for over 40 % of its carbon dioxide emissions. Lighting is a substantial energy consumer, and a major component of the service costs in many buildings. The percentage of the electricity used for lighting in European buildings is 50 % in offices, 20-30 % in hospitals, 15 % in factories, 10-15 % in schools and 10 % in residential buildings [3]. To promote the improvement of the energy performance of buildings within the community, the European Parliament has adopted the Directive 2002/91/EC on the energy performance of buildings. [4]

The average lighting system efficacy by region is estimatd to be 50 lm/W in North America, 54 lm/W in Europe, 65 lm/W in Japan, 49 lm/W in Australia and New Zealend, 58 lm/W in China, 43 lm/W in former Soviet Union and 43 lm/W in the rest of the world.

3 TRENDS IN ENERGY EFFICIENT LIGHTING

Electric light is provided as a result of combination of lighting equipment. A modern lighting system requires light sources, ballasts, luminaires and controls. Part of the power input to the lighting unit is transformed into light, while the rest is considered as loss. Energy is lost in lamps, luminaires and ballasts in the form of heat. The saving of lighting energy requires the use of energy efficient components as well as the application of control, dimming, and the use of daylight.

A 35 % improvement has been reported in efficiency of T5 fluorescent lamp using mirror louvre fixture over an equivalent T8 mirror louvre fixture when using a high-frequency ballast and a standard aluminum reflector. The corresponding improvement in efficiency for a luminaire of the same type with conventional ballast was about 65 %. [5]

In IEA Annex 45 one objective is to develop a lighting control system with high level of intelligence and multiple levels of control that learn and adapt to user's preferences and behavior. The usage of wireless sensors and actuators is a key component for new lighting control systems. It is also possible to integrate such a system into existing buildings. On the other hand is it impossible to realize an intelligent lighting system without a lot of sensors and actuators to capture and control the environment.

The Directive 2000/55/EC gives energy efficiency requirements for ballasts for fluorescent lamps. The maximum power of ballast-lamp circuit, for example, of a 36 W fluorescent lamp should be less than 45 W after 21 May 2002 and less than 43 W after 21 November 2005. [6]

High pressure discharge lamps are very energy-efficient lamp types. Their small discharge tube allows an efficient reflector design for luminaires so that the luminous flux from the luminaire can be distributed effectively in the room. Typically, it takes 3 minutes to reach 80% of the nominal luminous flux of a high pressure discharge lamp. For automotive lamps, this time has been reduced to 3 seconds already [7]. At present, high pressure discharge lamps cannot replace other lamp types.The reasons are in the start performance and in restricted dimming performance. Research on the interaction of ballast electronics and high pressure discharge lamps may significantly improve the performance of this lamp type.

LEDs (Light Emitting Diodes) are new alternative light sources, which are foreseen to revolutionise the lighting technology in the near future. According to Agilent Technologies the lumens/package value of red LEDs has been increasing 30 times per decade whereas the price is decreasing 10 times per decade [8]. The use of LED based lighting could decrease the lighting energy consumption by 50 % by 2025 [9]. The future entrance of LEDs in the lighting market is dependent on improvements in conversion efficiency and optical power per package. Although most of the high-power LEDs (HP-LEDs) nowadays convert between 15 to 20% of the input power into light, their efficiency potential is far better. In fact the best AlInGaP (aluminum indium gallium phosphide) red LED and InGaN (indium gallium nitride) green and blue LEDs can have internal quantum efficiencies which can reach almost 100% and 50%, respectively. To achieve external quantum efficiencies close to that magnitude, the light extraction has to be improved. By allowing more photons to escape from the LED chip without been absorbed by the surrounding structure, is one of the main design challenges which has to be addressed in order to increase the device conversion efficiency and the radiant power per device. New technologies have been developed in order to address this issue. The most promising one is the use of quantum dots or nanoparticles. Quantum dots are characterized by having a large absorption spectral range characteristic and a tunable spectral emission. This makes them ideal to substitute conventional and inefficient phosphors used today in white LEDs. However, improvements have to be done especially in the quantum efficiency of quantum dots.

The importance of LED lighting was acknowledged this year also by the Millennium Technology Prize Foundation. The 2006 Millennium Technology Prize, the world's largest technology award, was awarded to Professor Shuji Nakamura for his invention of the blue LED. [10]

4 IEA ANNEX 45

4.1 Objectives

The goal is to identify and to accelerate the widespread use of appropriate energy efficient high-quality lighting technologies and their integration with other building systems, making them the preferred choice of lighting designers, owners and users.

The aim is to assess and document the technical performance of the existing promising, but largely underutilized, innovative lighting technologies as well as future lighting technologies and their impact on other building equipment and systems (ie: daylighting, HVAC). These novel lighting system concepts have to meet functional, aesthetic, and comfort requirements of building occupants.

The aim is to assess and document the barriers preventing the adoption of these promising existing and future technologies (ie: technical, economic, risk factors, resistance to change, legislative, etc.) and propose means to resolve these barriers.

4.2 Structure

The Annex 45 will run between 2005 and 2008. The work of Annex 45 is divided to four Subtasks.

- Subtask A Targets for Energy Performance and Human Well-being
- Subtask B Innovative Technical Solutions
- Subtask C Energy-efficient Controls and Integration
- Subtask D Documentation and Dissemination.

Subtask A: Targets for Energy Performance and Human Well-Being

The objective are to document the effect of design and targets for energy use, lighting quality and human well-being. To propose an upgrade of lighting recommendations and codes to improve the energy performance of indoor lighting installations.

The performance criteria include the spectral, electrical and user related issues. The energy criteria include energy efficiency, life cycle energy considerations, maintenance and operation. The economical criteria include cost of devices and of application.

Subtask B: Innovative Technical Solutions

The objective is to identify, assess and document the performance, energy and economical criteria of the existing promising and innovative future lighting technologies and their impact on other building equipment and systems. The purpose is to reduce the energy use of buildings by investigating the saving potential by comparing the existing and future technologies and by applying information on concepts, products and lighting solutions. The technical solutions cover power supply, light sources, luminaries and concepts of controls.

Subtask C: Energy-Efficient Controls and Integration

The Subtask C focuses to optimal use of controls that enables energy savings whilst the user (occupant, facility manager, operation and maintenance team…) has the possibility to modify the electric lighting according to personal needs and preferences, within acceptable building operative requirements. Subtask C gives guidelines to designer, installers, manufacturers to achieve the above-mentioned aim.

Subtask D: Documentation and Dissemination

The objective of Subtask D is to improve current lighting practices in a manner that accelerates the use of energy efficient products, improves overall building performance and enhances the occupants' environmental satisfaction. The objective of Subtask D is to compile and widely disseminate the Annex research results and to identify the means to influence the energy policies and regulations in order to promote the use of energy efficient lighting. The main deliverables of the Annex will be Guidebook on Energy Efficient Electric Lighting for Buildings, semi-annual Newsletter, seminars and a website (http://lightinglab.fi/IEAAnnex45).

4.3 Management of the Annex 45

The Annex is managed by the Operating Agent with the assistance of the Subtask Leaders. Currently there are 20 participating and corresponding countries and 37 organizations in the Annex 45.

More information of the Annex can be found from the Annex web-site: http://lightinglab.fi/IEAAnnex45 or from Liisa Halonen (liisa.halonen@tkk.fi) or Eino Tetri (eino.tetri@hut.fi) from Helsinki University of Technology.

5 ENERGY SAVINGS – CASE OFFICE LIGHTING

Measurement of the power used by the office rooms of HUT Lighting Laboratory in Finland was done during all four seasons of the year and the annual energy consumption was calculated based on the measured values. The Lighting Laboratory building was built as a demonstration building for lighting research. The rooms of the building are equipped with the variety of lighting control systems including both old manual system and newest technologies for the integration of artificial and natural lighting.

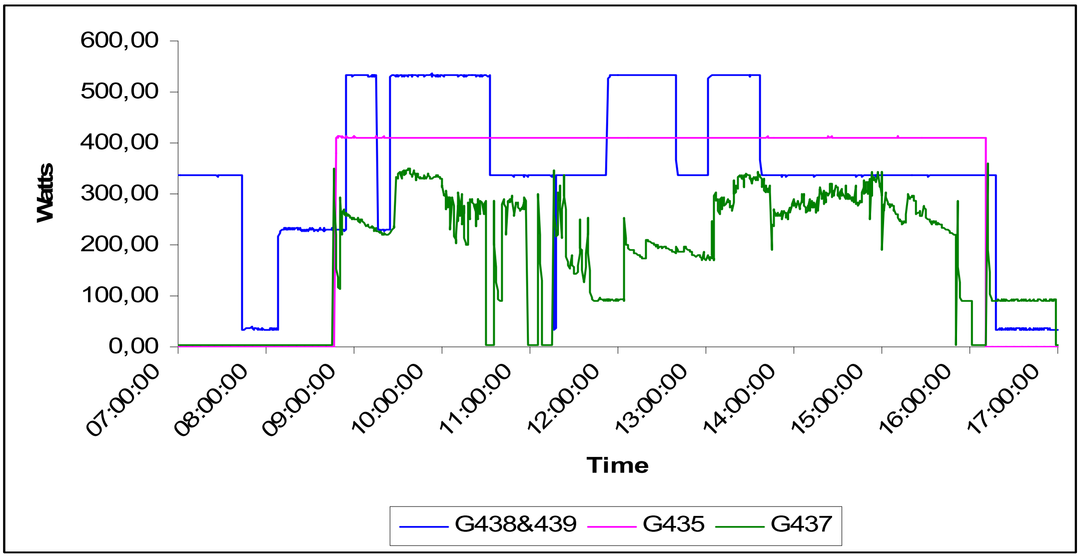

Figure 1 Power consumption curve for rooms G435, G437, and G438&439

Three sets of rooms (G435, G437, and G438&439), each with different lighting control system was chosen for the measurement and assessment. All the rooms were equipped with T5 (35 W and 28 W) fluorescent lamps (CCT = 3000, and CRI>80). Room G435 has only manual up/down lighting control system whereas room G437 has a constant light control with a photosensor, rotary control switch and occupancy sensor. Only occupancy sensor control was used in the rooms G438&439. As seen in the power curve (Figure 1), the room G435 uses full installed power all the time. Rooms G438&439 also use full installed power, but only when the rooms are occupied. Due to the combination of dimming according to daylight and occupancy control, the power curve of room G437 is changing over short intervals. It uses full installed power only when the daylight is completely unavailable.

Table 1 Measured values of illuminance, glare rating, installed power, and energy consumption

Rooms	Average Illuminance in lx		UGR	W/m^2	kWh/m^2
	Working plane	Floor			
G435	575	380	11	14,1	33
G437	665	390	16,4	16,9	20
G438&439	704	501	11,5	16,3	24

UGR = Unified Glare rating
W/m^2 = Installed power for lighting per square metre of room, in W/m^2
Wh/m^2 = Annual energy consumption per square metre of the room, in kWh/m^2

Room G437 has highest (16,9 kW/m^2) and the room G435 the lowest (14,1 kW/m^2) installed power for lighting, but due to daylight based dimming and occupancy control in room G437, it consumes the least energy (20 kWh/m^2 per annum) compared to 24 kWh/m^2 of rooms G438&439 (only occupancy control) and 33 kWh/m^2 of room G435 (manual control). On the other hand, as seen in the Table 2, the working plane illuminance in the room with high energy consumption is lower compared to the other rooms. The energy consumption for rooms except the one with manual control is well below the average annual energy use for lighting in Finnish offices, which is 31 kWh/m^2 (Korhonen et al., 2002). The average working plane illuminance levels of all these rooms (Table 1) are higher than the current recommendation level (Table 1), so there is still possibilities to reduce the annual energy consumption level below 20 kWh/m^2 without compromising lighting quality.

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PHOTOMETRY AND COLOURIMETRY OF LED CLUSTERS

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ABSTRACT

As the application of solid state lighting has become more and popular in various fields, LEDs provide a challenge to the light measuring community to provide adequate measuring solutions. Although some measurement issues regarding single LEDs have already been addressed, no accurate photometric and colourimetric techniques and standards for LED cluster measurements have been established. In light of the above, the paper aims to address how LED cluster measurements can be performed, what issues should be taken into consideration when performing such measurements and what the implications for the lighting community are. In an effort to answer the above, an experiment was conducted where seven LED cluster samples were examined in terms of photometry and colourimetry. The paper explains the methodology and results of the experiment, investigates photometric and colourimetric issues, examines the conditions under which such measurements should be performed, analyses the importance of measurement results, investigates the consequences of such conclusions in practise, examines possible future implications, and provides recommendations for performing accurate measurements. The findings of this paper should be considered with respect to the current technology and should form the basis for future research due to the fact that production and measurement techniques are changing rapidly.

1 INTRODUCTION

With the introduction of LED Clusters as a replacement for traditional sources in an increasing range of applications, LED Clusters- and not just single LEDs- provide a challenge to the light measuring community to provide adequate techniques, accurate standards, and devices for LED Cluster measurement (1).

The current literature on LED technology and the current state of optical measurements of LEDs and standardization efforts primarily in CIE illustrate that the lighting industry has addressed and solved some measurement issues regarding single LEDs (2). At the same time, however, some other issues are still debated especially regarding LED Clusters. In fact, there has been some effort to address such measurement issues, for instance, by the CIE Technical Committee TC2-50. Nevertheless, the research on this field is very limited and no accurate photometric techniques and standards for LED Clusters measurements have been established yet.

2 LED PHOTOMETRY AND COLOURIMETRY

A prime concern of the LED measurement industry is the high levels of uncertainties and inconsistencies found in measurement results (3), (4). Moreover, new developments in instrument design open up new methods of measurement, while new LED structures require some product specific measurements (5). It is therefore necessary, to take into account the small dimensions, the spectral distribution and the spatial distribution for performing reproducible and accurate measurements of LEDs (6).

2.1 LED Photometry

Research on LED measurements is currently undertaken at many National Metrology Institutes (7). For instance, the Commission International de L'Eclairage (CIE) maintains an interest in all areas of light measurement. In particular, the CIE Publication 127, 1997, defines the problems related to the measurement of LEDs (8) and provides recommendations of how to reduce measurement uncertainties (9). In particular, in order to achieve reproducibility the 'Averaged LED Intensity' was defined (10) and standardized measurement geometries were introduced (11), (12).

2.1.1 The Goniophotometer
The most common and accurate way to measure the luminous intensity of a source is to use a Goniophotometer. There are no set protocols for LED goniometry. One goniometric measurement system that can be used is the (C, G) planes, as defined in the BS EN 13032-1:2004 (13). The detector is then used to determine illuminance (E) which is converted to intensity (I) (by applying the inverse square law), arising as a function of the rotation angles.

2.2 LED Colourimetry
CIE colourimetry provides a quantitative and qualitative description of colour. It is based on the assumption that every colour is a combination of the three primary colours: Red, Green and Blue. In 1931 the CIE established the (*x, y*) diagram which, however, is very non-uniform in terms of minimum perceptible colour differences. To get round this problem the Uniform Colour Space (UCS) diagrams were developed, where the MacAdam ellipses have similar areas (14). In these diagrams, Correlated Colour Temperature (CCT) is depicted on the full radiator locus.

2.2.1 LED Spectral Distributions
The spectral distribution of the optical radiation emitted by LEDs distinguishes them in various aspects from other sources of optical radiation. The radiant power is neither monochromatic nor broad-band but something between the two. In addition, they have a spectral bandwidth of some tens of nanometers and a peak wavelength somewhere in the visible or near infrared region of the spectrum (15) which depends on the manufacturing process of the LED.

2.2.2 The Spectroradiometer
Spectral measurements are performed using a spectroradiometer. This consists of a monochromator, a photodetector and some means of converting the output readings into relative spectral power values. The monochromator consists of an entrance slit, a collimating device, a dispersing element - usually a diffraction grating- and an exit slit (16).

3 METHODOLOGY

3.1 LED Cluster Samples
The following seven LED Cluster samples were used in the experiment:
- SAMPLE (A): High Power Cool White MR16 with 3 LEDs (10V, 1,2W per LED)
- SAMPLE (B): High Power Warm White MR16 with 3 LEDs (10V,1,2W per LED)
- SAMPLE (C): Low Power MR16 RGB with 36 LEDs (24V, 0,1W per LED)
- SAMPLE (D): Low Power PCB with RGB 90 LEDs Narrow Beam (24V, 0,07W per LED)
- SAMPLE (E): Low Power PCB with RGB 90 LEDs Wide Flood (24V, 0,07W per LED)
- SAMPLE (F): Low Power Cool White MR16 with 36 LEDs (12V, 0,1W per LED)
- SAMPLE (G): Low Power Warm White MR16 with 36 LEDs (12V, 0,1W per LED)

3.2 The Goniophotometer
A Goniophotometer was constructed in order to perform the photometric measurements in (C, G) planes (illustrated by movements B and C respectively). The photometric center of each sample was also adjusted (by a movement in the direction A) as depicted in the sketch.

Figure 1 Mechanical Movements of Goniophotometer (17)

3.3 Experimental Conditions
Measurements took place in a dark room. The illuminance meter was positioned exactly opposite from the photometric center of each LED Cluster. For the High Power LEDs, the above distance was defined

at 2 meters where uniform and diffuse light was emitted. For the Low Power RGB Clusters, the distance was defined at 1 meter where uniform, diffuse, white light without any spill coloured light was emitted.

3.4 Stability Test

When the first photometric measurements were recorded, the results were very inconsistent. For that reason, it was decided to perform a stability test. Each Cluster was placed into a separate box and was covered with a black cloth, so as to ensure that no surround light penetrated the boxes. Inside each box and underneath the LED Clusters, a photocell was placed. In turn, the photocell was connected to computer software which was logging the values from the light meter. In particular, the light output of the LED was sampled every 10 seconds for a period of 3 hours for some samples or overnight for some other samples.

The Stability Test started after each LED Cluster had been running for 15 minutes, and sampled the light output of the LED every 10 seconds. In addition, the condition of 1% variation in 15 minutes was used to assess stability.

3.5 Photometric Measurements, Luminous Intensity & Luminous Flux

Photometric measurements were undertaken after ensuring that each of the LED Clusters had been running for as long as necessary to achieve stability. Under all circumstances, measurements were made under conditions where the distance between the exit window of the LED Clusters and the illuminance meter was such that it could be treated as if it was emitted by a point source, thus obeying the inverse square law, with the intensity pattern depending on the distance from the illuminance meter. In all cases, the surround illuminance of 0.04lux generated from the surrounding was deducted from all illuminance readings. In turn, luminous intensity and luminous flux were calculated.

For the RGB Clusters, illuminance measurements were made for each colour independently. The readings of each colour where added together and, resulted the illuminances readings of white colour emitted at full power.

3.6 Colour Measurements, Chromaticity Coordinates & Correlated Colour Temperature

The true spectral power of the single colour LED Clusters was multiplied by the spectral tristimulus values (X coefficient, Y coefficient and Z coefficient) of the appropriate colour matching functions. The sums of these products gave the X, Y, and Z values respectively. In turn, from these values the x, y, z were calculated as follows:

$$x = \frac{X}{X+Y+Z} \quad (1)$$

$$y = \frac{Y}{X+Y+Z} \quad (2)$$

$$z = \frac{z}{X+Y+Z} \quad (3)$$

Where: $x + y + z = 1$.

In the case of RGB LED Clusters, chromaticity coordinates were calculated at each point of (C, G) angles of the intensity table for each colour independently, using the Relative Scaled Factors so as to account for the contribution of each colour. The Relative Scaled Factors are defined as follows:

$Yrelative = Lumens(y)$, where y= the total lumens or the lumens of a specific point of (C, G) angles of the intensity table emitted by the Red or Green or Blue LEDs of the Cluster).

$Xrelative = X * y / Y$, where y=lumens as defined above

$Zrelative = Z * y / Y$, where y=lumens as defined above.

Chromaticity coordinates at full power were converted to RGB values (18), (19), in order to depict the colour of the emitted light and present this in the photorealistic software AGI 32. Finally, CCT was calculated for the single colour LED Clusters, as well as for the RGB Clusters when operating at full power.

4 RESULTS

4.1 Stability Results

Sample (A) achieved stability in 40min. Sample (B) in 2hrs 14min, sample (C) in 20min, sample (D) in 2hrs 48min, and sample (E) in 15min. Sample (F) and (G) did not reach stability during the period of examination. Some reasons that could explain this include the transformer specifications or the fact that the sample was new and was still burning down. In all cases, it was assumed that the particular LED Clusters would not achieve stability within a reasonable time period, thus it was decided not to analyze the samples any further.

4.2 Illuminance Measurements, Total Luminous Flux & Polar Curves

Total Luminous Flux was calculated from illuminance measurements. The results are presented in Table 1.
In turn, Intensity Distribution Curves were generated for each colour emitted by the LED Clusters. An example is shown in Figure 2.

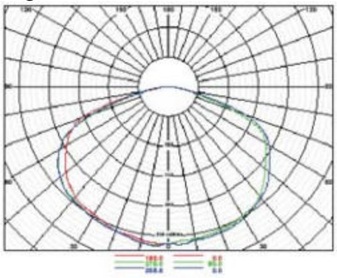

Figure 2 Polar Curve of white light emitted by Sample (E)

Table 1: Total Luminous Flux

LED Cluster	Total Luminous Flux (lm)
High Power Cool White	44.22
High Power Warn White	35.06
RGB MR16 24V- Red	4.75
RGB MR16 24V- Green	12.39
RGB MR16 24V- Blue	7.56
RGB MR16 24V- White	25.19
PCB 90LED Narrow Beam- Red	22.37
PCB 90LED Narrow Beam - Green	27.24
PCB 90LED Narrow Beam - Blue	17.96
PCB 90LED Narrow Beam - White	68.07
PCB 90LED Wide Flood - Red	16.13
PCB 90LED Wide Flood - Green	23.26
PCB 90LED Wide Flood - Blue	11.16
PCB 90LED Wide Flood - White	51.05

4.3 Colour Measurements, Chromaticity Coordinates & Correlated Colour Temperature

The scaled results of the Spectral Distributions were calculated. In turn, chromaticity coordinates as well as the respective RGB Values were calculated. Finally, CCT was calculated.

Table 2: Chromaticity Coordinates, RGB Values & CCT

LED Cluster	x	y	z	R	G	B	CCT (K)
High Power Cool White	0,308827	0,295111	0,396062	246	216	255	7600
High Power Warm White	0,333998	0,332549	0,333453	255	224	220	5600
RGB MR16 White (full power)	0,240442	0,28924	0,470318	91	197	255	12300
PCB Narrow Beam White (full power)	0,303549	0,26002	0,436431	242	184	255	10100
PCB Wide Flood White (full power)	0,295034	0,263563	0,441403	246	185	255	10400

5 DISCUSSION

5.1 Discussion on Photometry

The experiment has shown that *Different LED Clusters have Different Stability Characteristics*. The Clusters achieve stability in different time periods, which suggests that investigating and providing stability specifications for LED Clusters can be very time consuming and expensive. Yet, the provision of such information is essential for the lighting community which nowadays relies on LED technology for general and architectural lighting applications.

At the same time, the *Different Spatial Distributions of Luminous Intensity* (polar curves) *show the considerable variety* that can be found in LED Clusters. The variety of luminous intensity may depend, amongst other things, on the LED construction and power specifications. In all cases, however, the considerable variety of LED Clusters in terms of photometry implies that lighting designers have a wide range of LED products available to realize lighting design schemes.

However, as in the case of single LEDs (20), LED Clusters do not necessarily show perfect axial symmetry. On the contrary, *LED Clusters can sometimes present asymmetric spatial distributions*. This suggests that the selection of LED Clusters for the architectural lighting applications should be performed after careful examination of their light output characteristics and specifications.

Additionally, it can be concluded that *High Power White LED Clusters differ in terms of Total Luminous Flux and Light Appearance from Low Power RGB LED Clusters*. In particular, the experiment has shown that the High Power LED Clusters have a higher luminous flux than the Low Power RGB LED Cluster. However, the latter has the benefit of producing almost any colour by mixing the three primary colours, plus white. In addition, the PCBs (which are 2cm larger in diameter than the MR16 samples) produce higher light output than the High Power LED Clusters, and can also produce many different colours plus white. Consequently, this raises questions as to whether or not the higher light output of High Power white LED Clusters justifies their high commercial cost.

Nevertheless, it should be reminded that L*ED Clusters have lower light output specifications than most conventional light sources*. Subsequently, the questions are how feasible it is going to be for LED Clusters to replace conventional light sources in the future, when this is actually expected to happen, and how will the growth of white LEDs affect the market of conventional light sources.

5.2 Discussion on Colourimetry

The experiment has indicated that Chromaticity Coordinates (x, y) can be easily calculated for the white light of the High Power LED Clusters at full power. These points can then be easily defined on the CIE Chromaticity Diagrams.

Chromaticity coordinates of RGB LED Clusters can be calculated not only for the white light emitted at full power (all Red, Green, Blue LEDs at full power) *but also for any other point of (C, G) angles of the intensity tables*, since the beam changes colour due to the fact that the separate colours of the cluster do not have identical photometric distributions. In turn, the chromaticity coordinates can be depicted on the CIE Chromaticity Diagram in order to define the colour of the emitted light. In particular, the CIE Diagrams below plot all the (x, y) values that correspond to the peak intensity value of the RGB LED Clusters at full power and at around 5% off peak.

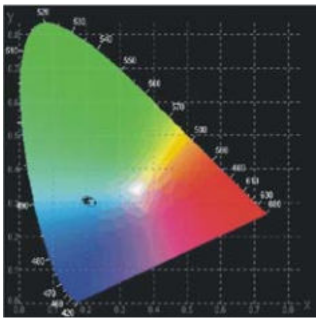
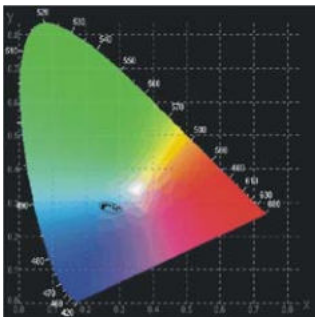
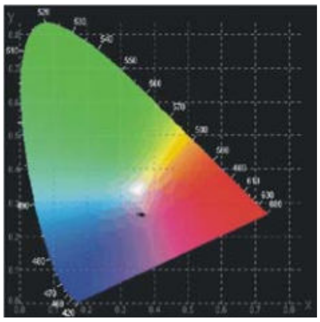

Figure 3 Sample (C) **Figure 4** Sample (D) **Figure 5** Sample (E)

The points on the CIE Diagrams correspond to different points within the spatial distribution from each Cluster and suggest that the colour of the emitted light is different when the LED Cluster operates at full power and different at various other intensity values. For that reason, a ring has been drawn round the points (x, y values) on the CIE Diagrams. *The size of the rings round the points could then be used as some form of metric of colour stability across the beam*. Thus, the smaller the size of the ring, the more colour stability exists across the beam and more uniform in terms of colour the emitted light is. On the contrary, the bigger the size of the ring, the more unstable the colour is across the beam.

6 CONCLUSIONS

During the experiment, many difficulties have been encountered, including the construction of the goniophotometer, working in darkness for a long period of time, defining manually and in precision the (C, G) angles, making measurements after a quite long period of time in order to ensure stability. Moreover, different methods and equipment could not be used due to time restrictions and the fact that no other equipment was available. Furthermore, the production techniques of the Clusters were not analyzed due to time constraints and the non availability of such information for all Clusters.

Nevertheless, several conclusions were drawn as discussed above. However, these conclusions should be treated with caution due to the fact that all measurements were made manually, thus a certain percentage error is expected in the measurement results. Also, the findings should only be considered with respect to the current available technology and should form the basis for future research due to the fact that the technology of LEDs and measurement techniques are changing rapidly.

7 IMPLICATIONS

It is very essential that LED makers provide stability specifications for the LED Clusters they produce. In light of this, one of the issues that should be considered in cases of mass LED production is the following: if different LED Clusters have different stability characteristics, then this may suggest that LED Clusters of the same type but of different production line may also differ in their stability characteristics. LED manufacturers need to investigate this issue. Additionally, LED manufacturers should try to investigate the possible variability of LED Clusters due to different production techniques.

Moreover, the question of why some LED Clusters do not achieve stability at all needs to be addressed. On the one hand, this is a crucial issue to the measuring specialists. On the other hand, lighting practitioners need to be aware of the Run Up time of the LED Clusters.

Furthermore, the great variety of luminous intensities of LED Clusters generates associated difficulties of defining a uniform method of measuring and characterization of LED Clusters. In addition, the asymmetric spatial distributions can lead to alignment problems. Nevertheless, measurement specialists should always take into consideration the unique nature of the Test LED Clusters, i.e. construction and power specifications.

Moreover, LED makers can define the colour of the emitted light from single or RGB LED Clusters on the CIE Chromaticity Diagram. The ring plotted on this diagram for RGB Clusters could then be used as an indication of the colour stability across the beam. In turn, this information can provide direction to future product developments and for lighting designs as well.

Additionally, the Correlated Colour Temperature of LED Clusters needs to be examined by LED makers. Indeed, not only do LED makers need to provide data on CCTs, but also to investigate ways of producing warm white light from LEDs. Finally, future research and development could also investigate into production processes of LED Clusters that emit high light output.

8 RECOMMENDATIONS

It is a fact that measuring LED Clusters is a time consuming and demanding process. For this reason a list of recommendations is provided below for accurate and reliable photometric and colourimetric measurements of LED Clusters.

Characteristics of the sample:

- Consider the construction and ageing characteristics.
- Take into consideration Thermal characteristics.
- Consider Stability characteristics.

Characteristics of operating equipment:

- Account for characteristics of transformer/ driver/ power supply.

Electrical conditions:

- Be aware of supply voltage, current and stability.

Geometrical conditions:

- Use goniophotometer for accurate photometric results.
- Define appropriate distance between Test sample and illuminance meter.
- Define goniometric system, i.e. (C, G) angles.
- Identify photometric center.

Stability conditions:

- Ensure the Test sample operates for at least as long as necessary to reach stability.
- If necessary perform Stability Test before making measurements.

Photometric Measurements:

- Treat the sample as point source and use the inverse square law formula.
- For RGB LED Clusters, measurements should be made for each colour independently.
- Determine (C, G) angles for which measurements will be made. Make the decision depending on how consistent the illuminance readings are between the different points of (C, G) angles.
- Deduct offset (surround light) from measurements.

- Calculate Total Luminous Flux with the use of Zone Factors.
- Express intensity results in candela per 1000 lumens to be easily identified by lighting designers.
- Convert intensity results to IES files to use in photorealistic programmes such as AGI32.

Colourimetric Measurements:

- Consider characteristics of measurement equipment, i.e. bandwidth, step interval etc.
- Consider calibration of the Absolute Irradiance Standard, i.e. reproducibility of lamp calibration conditions.
- For RGB LED Clusters, spectral power distribution measurements should be made for each colour independently.
- Deduct offset from measurements.
- Apply Scale Factor.
- Calculate Chromaticity Coordinates and define the colour of the emitted light by locating the point on CIE Chromaticity Diagram.
- Draw rings around the x, y values that correspond to the peak intensity and around the peak. The size of the ring could be used as some form of metric of colour stability across the beam.
- Convert x, y values to RGB values to use in photorealistic programmes such as AGI32.
- Calculate Correlated Colour Temperature.

Other considerations:

- Think of LED Cluster safety issues.
- Consider ambient temperature.

Percentage error:

- Account for a percentage error when making measurements manually.
- Consider colour correction errors of photometers and tristimulous colourimeters.

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PRECISE LIGHT INTENSITY DISTRIBUTION CONTROL OF COMPACT LUMINAIRE FOR MULTI PURPOSE LIGHTING ENVIRONMENT

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ABSTRACT

Recently, an interest in the comfortableness for lighting environment is growing day by day along with the progress of office automation. Then, the development of prominent luminaire, which can control precisely light intensity distribution without glare and consumes a little amount of energy, has principal importance for the accomplishment of highly comfortable lighting environment without architectural restriction. Luminaire reflector up to this day has been made up of cylindrical surface, elliptic surface, parabolic surface and plane surface. These reflectors, however, can not reflect the rays emitted from fluorescent lamp to predetermined directions appropriately, so that the precise control of light intensity distribution is difficult, and the improvement of luminaire efficiency is suspended.

In this study new unique curved surface called " Super parabolic curved surface ", which makes possible to reflect the rays emitted tangential to cylindrical circle from fluorescent tube surface to the direction with predetermined vertical angle, has been adopted so as to control precisely light intensity distribution and to improve the efficiency of light output from luminaire.

In this study, three dimensional optical analyzing system for luminaire design has been developed, and eminent luminaire reflector which can control precisely light intensity distribution with high efficiency and whose size is also adjusted architecturally adequate size, has been designing optically with the aid of computer analysis to actualize high comfortable lighting environment.

1 INTRODUCTION

New method how to design fluorescent luminaire reflector which could control adequately and precisely light intensity distribution has been developed by using unique curved surface in terms of computer aided analysis. Unique curved surface can control precisely directions of reflected rays so as to produce suitable light intensity distribution and to eliminate unnecessary rays causing glare.

A light source installed within a luminaire can not be treated as an uniform source with equal luminance distribution. Because reflected rays from the reflector may come back to the source surface, and may result in non-uniform luminance distribution on the source surface. Non-uniform increment of the lamp luminance due to the inter-reflection between the reflector surface and the source surface is not able to be ignored for the precise estimation of the luminous intensity distribution.

New algorithm using a repeating ray-tracing method has been developed for the analysis of the luminance increment on the lamp surface. Repeating calculations considering the inter-reflection is executed, regarding the lamp surface and the reflector surface as secondary luminous sources, so that diffusely reflected rays are estimated and accumulated on the lamp surface to estimate final non-uniform luminance distribution on the lamp surface .

In this study, Typical light intensity distributions of 6 patterns which are appropriate for office lighting have been obtained by new luminaire reflectors composed of combinations of the unique super parabolic surface and plane surface. By considering non-uniform luminance distribution, the simulated luminous intensity distribution is well in accord with the measured data of a sample luminaire, and the simulated luminous efficiency is also consistent with the practical data.

2 SUITABLE LIGHT INTENSITY DISTRIBUTION

Light rays emitted in the direction of vertical angle within from 15 to 35 degree and over 60 degree should be suppressed so as to eliminate the glare caused by direct rays from the source, specularly reflected rays on the

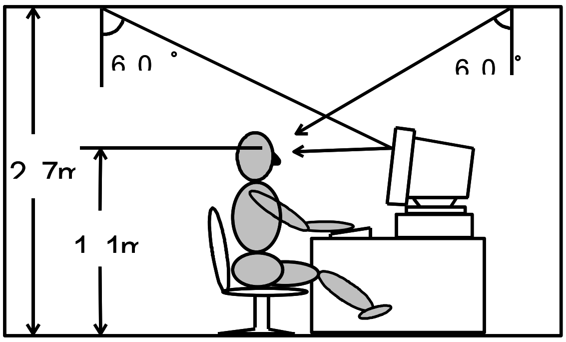

Figure 1 Light reflection on VDT tube and light entering directly into eyes

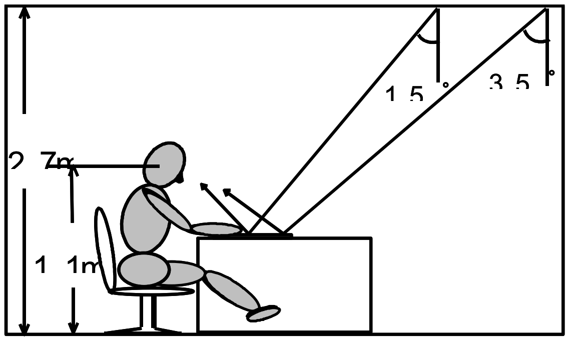

Figure 2 Light reflection on a book and a desk

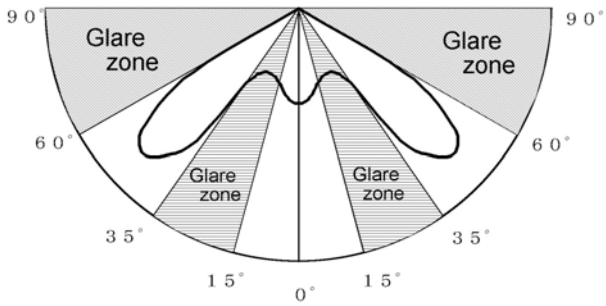

Figure 3 Suitable light intensity distribution

surface of a VDT tube or diffusely reflected light from the surface of a paper on a desk etc.

Figure 1 shows a model figure of the glare arising from the reflected light on VDT tube and the light entering directly into eyes. Figure 2 shows a model figure of the glare arising from the light reflection on a book and a desk. An example of suitable light intensity distribution is shown in Figure 3.

3 CURVED SURFACES FOR LUMINAIRE REFLECTOR

Parabolic curved surface. The parabolic curved surface control rays from a source located at the focus so as to form parallel beamed rays directed to specified course as shown in Figure 4. The equation representing the cross section of this curved surface is given below.

Super parabolic curved surface. The super parabolic curved surface is developed to control adequately and precisely light intensity distribution. This curved surface has focus on a circle with radius of R, i.e. on the surface of fluorescent tube, and redirects rays emitted tangential to cylindrical surface of the tube to predetermined direction so that the reflected rays are confined within the angular domain bounded by the vertical control angle as shown in Figure 4. Under the control angle, the light returning to the tube surface does not exist.

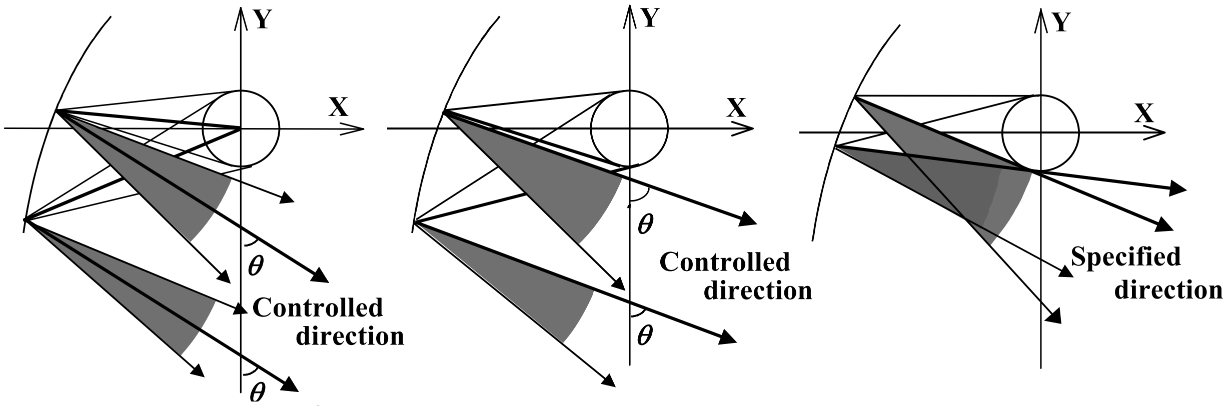

Figure 4 Parabolic curve, Super parabolic curve and Involute curve

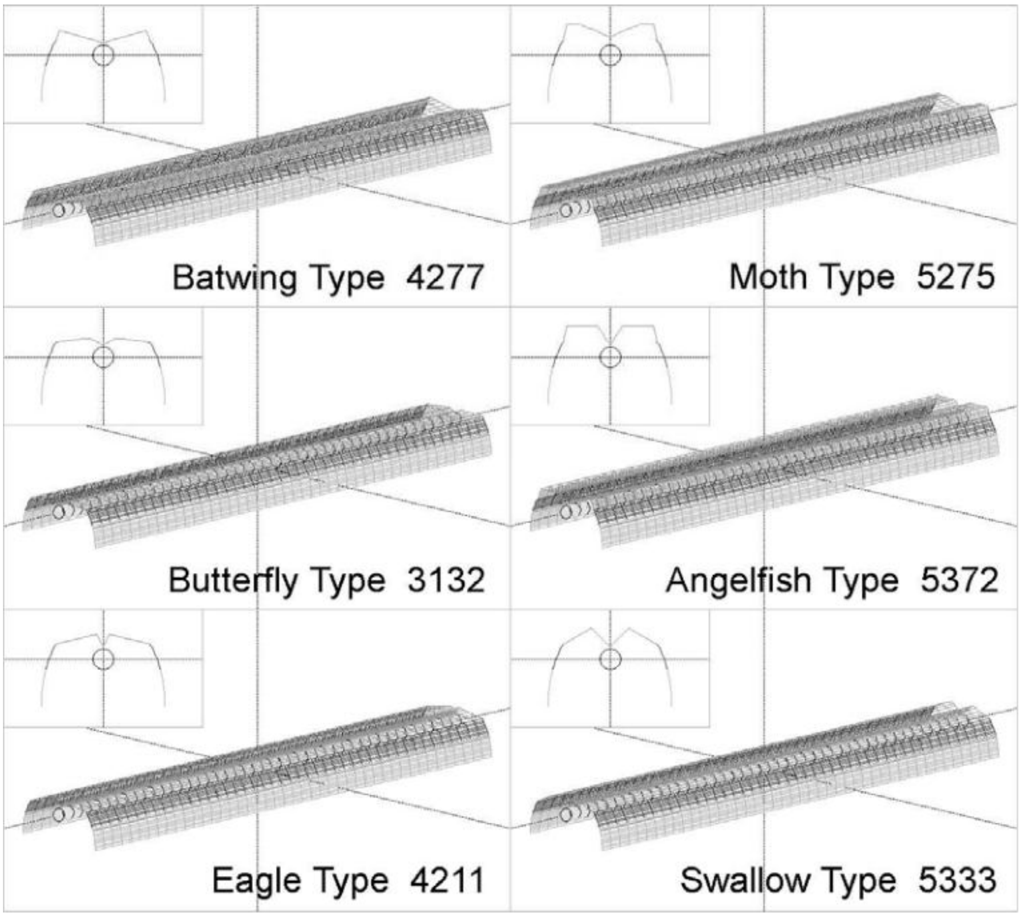

Figure 5 Typical shapes of luminaire reflector

For usual fluorescent lamps, this curved surface is the most preferable to control exactly luminous intensity distribution with high efficiency.

Involute curved surface. The involute curved surface reflects rays radiated tangential to circular surface of a fluorescent tube to reverse directions of incidence as shown in Figure 4. So the reflected rays could not be intercepted by the tube nor absorbed by reflector surface. This curved surface is employed mainly for the upper part of the reflectors.

4 OPTICAL DESIGN OF LUMINAIRE REFLECTOR

A luminaire reflector is divided into three sections and a suitable curved surface is applied to each section for proper control of reflected rays. A shape of each reflector surface with control angle of θ and cut-off angle of ϕ is calculated approximately as a series of sequential hyperfine lines according to Runge-Kutta method by analyzing a parametric differential equation which specifies the function representing the shape of each section.

A shape of the reflector surface is designed by using various special curves. Special curves for the reflector are adopted such as traditional parabolic curve and unique super parabolic curve which can control adequately and precisely light intensity distribution by considering a finite diameter of cylindrical coaxial source. Typical shapes of luminaire reflector are shown in Figure 5.

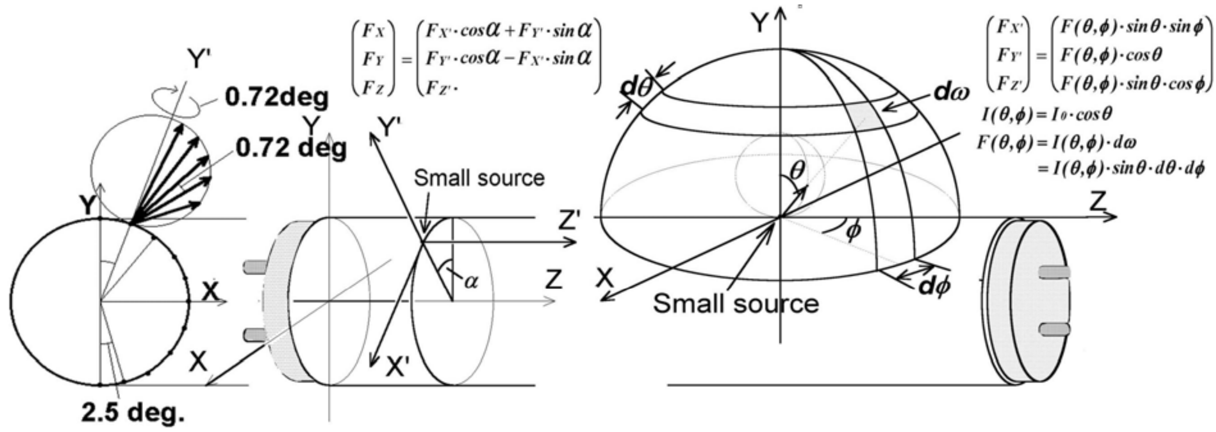

Figure 6 Emitting light flux on the lamp surface

5 PREDICTING CALCULATION OF LIGHT INTENSITY DISTRIBUTION

At the start of calculation, the surface of fluorescent tube is divided into 72 sectors along a circle perpendicular to the tube axis. Each sector is regarded as a small source and is assumed to radiate 62500 light rays according to Lambert's cosine law as shown in Figure 6.

Each ray emitted from the lamp surface is pursued three dimensionally in terms of ray tracing method and is classified into one of four sorts, i.e., directly exit ray without reflection, ray which is reflected by reflector surface and then goes out luminaire aperture, returning ray to the lamp surface after reflection on the reflector surface or extinguished ray on account of multiple reflection on the reflector surface. In each calculation, light ray which is represented as vector flux multiplied by the solid angle is chased three dimensionally until it escapes from exit aperture of the luminaire and summed at infinite distance.

Specular reflection and diffuse reflection:
Specularly reflected ray and diffusely reflected ray are analyzed separately on this program. Specularly reflected ray is pursued by means of ray tracing method. As for diffusely reflected ray, optical behavior is evaluated by calculating repeatedly according to secondary luminous source algorithm which is developed in our laboratory.

All diffusely reflected rays are traced and accumulated on the reflector surface until the light quantity on the surface reaches steady amount. Then the light intensity distribution is estimated on the assumption that each element of the reflector is a small diffuse light source.

Luminance distribution on the lamp surface:
Returning light ray on the tube surface is divided in to specularly reflected ray on the glass surface, diffusely reflected ray and diffusely transmitted ray through the fluorescent layer.

Specular reflectance on the glass surface is expressed as a function of incident angle derived from Fresnel's formula, and specular reflectance, diffuse reflectance and diffuse transmittance on the fluorescent layer are also obtained experimentally as a function of incident angle.

For the analysis of luminance increment on the lamp surface, repeating calculation considering the inter-reflection between the reflector surface and the source surface is executed according to secondary luminous source algorithm which is developed in our laboratory.

All diffusely reflected rays and diffusely transmitted rays, which contribute to the non-uniform increment of the luminance on the tube, are estimated and accumulated until the light quantity on the tube surface reaches steady amount according to the same algorithm stated above.

Then the fluorescent tube is treated as diffuse light source with non-uniform luminance in this program.

After final luminance distribution on the tube is estimated, calculation starts again according to accumulated luminance distribution as secondly light source.

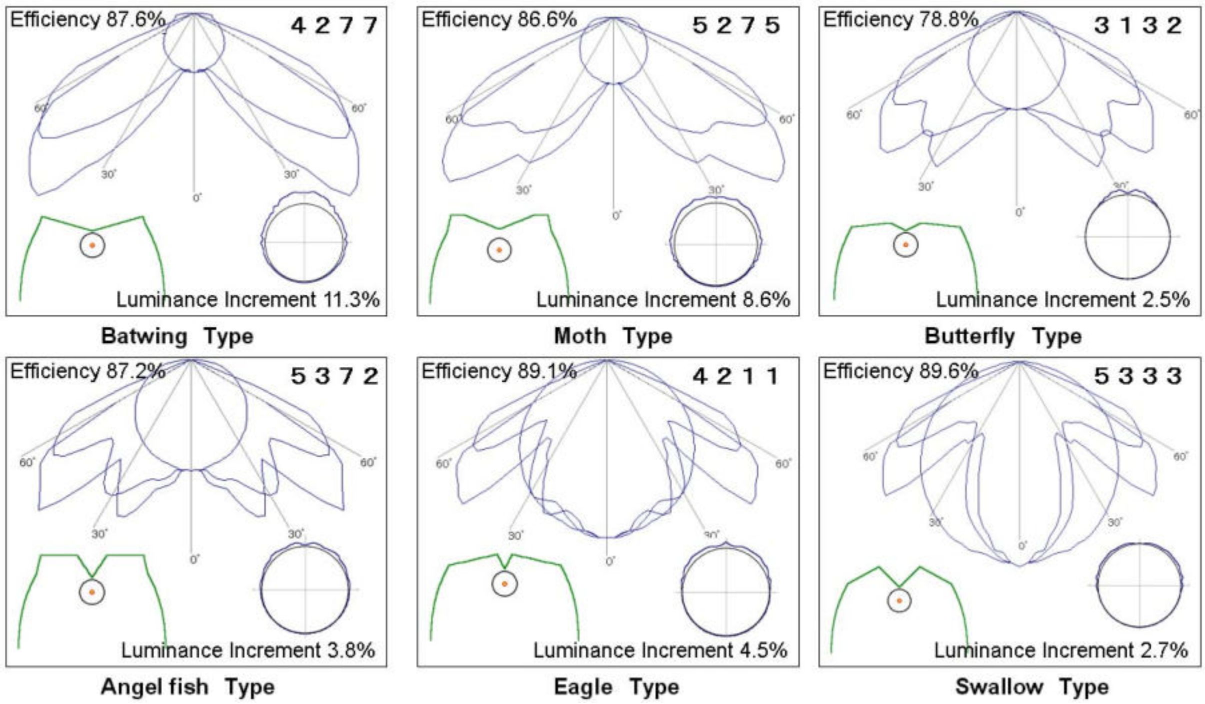

Figure 7 Some examples of luminaire reflectors with super parabolic curved surface and light intensity distributions of luminaires. Curves central upper part show light intensity distributions in A-A, B-B and C-C sections. Figures lower left and lower right show the shape of reflector and inhomogeneous luminous increment on the lamp surface, respectively.

6 ESTIMATED LIGHT INTENSITY DISTRIBUTION

Typical 6 patterns of eminent light intensity distributions have been obtained by using unique super parabolic curved surface, and each distribution has been named as "**Batwing Type**", "**Moth Type**", "**Butterfly Type**", "**Angelfish Type**", "**Eagle Type**" or "**Swallow Type**", respectively.

Some calculated light intensity distributions for typical models of fluorescent luminaire reflectors are shown in Figure 7. These figures present light intensity distributions in the case that the height of the luminaire is sufficiently large. Luminaires are composed of reflectors with specular reflectance of 90% and diffuse reflectance of 0%. As for this type of luminaires, rays over the cut-off angle are suppressed completely.

The predicted light intensity distribution of Batwing type is well in accord with the measured data, and predicted efficiency is also close to the measured one. The light output ratios of these luminaires in this study are considerably higher than those of traditional ones, and the characteristics of light intensity distributions are superior to those of ones up to now.

7 ANALYSIS ON FLOW OF LIGHT FLUX IN LIGHTING SPACE

The distribution of spatial luminance and aspects of the flow of light fluxes in interior room space are analyzed by means of chasing rays exit from each small opening on the surface of the luminaire.

The model that equipped four luminaires on the ceiling of the lighting space is assumed in order to calculate the three dimensional spatial luminance distribution.

Light sources with same type of the luminaire are equipped on appropriate positions of the ceiling with height of 2.7 [m] in three dimensional room space.

Optical characteristic of the surface of each light source is set up same as partitioned light intensity distribution data of the small opening in order to reproduce the characteristics of light intensity distribution of the luminaire precisely.

In other words the surface of the light source equipped on the ceiling has been divided in to 4 [cm] square apertures, and light intensity distribution data of each square is set to the same partitioned light intensity distribution of the small opening of the luminaire as mentioned above.

Each opening surface is assumed to emit rays in every direction according to the angle characteristic of partitioned light intensity distribution data as point light source existing in the centre of each small square on the surface of the light source.

Size of the lighting space to be analyzed is assumed to have dimensions with width 8.1 [m], depth 8.1 [m] and height 2.7 [m], and three horizontal planes are presumed to have heights of 0 [cm], 90 [cm] and 180 [cm] from the floor plane. Each plane on respective height is divided into 27×27 small squares at 30 [cm] interval as shown in Figure 3.

In the course of ray purchasing, the position of the square through which each light ray passes is searched and identified, then the angle and the strength of each passing ray through the square surface are recorded.

In each small square segment, respective light intensity distribution is added up, then the illuminance and the luminance distribution which show the strength and the direction of propagating light flux on arbitrary section in the model space are evaluated successively.

The illuminance and the luminance might be called the spatial illuminance and the spatial luminance.

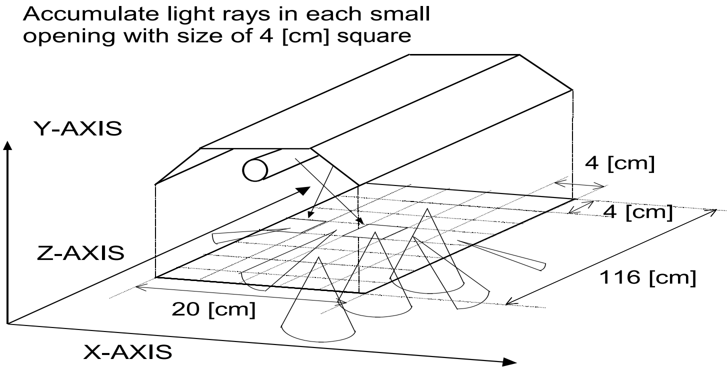

Figure 2 Partitioned light intensity distribution

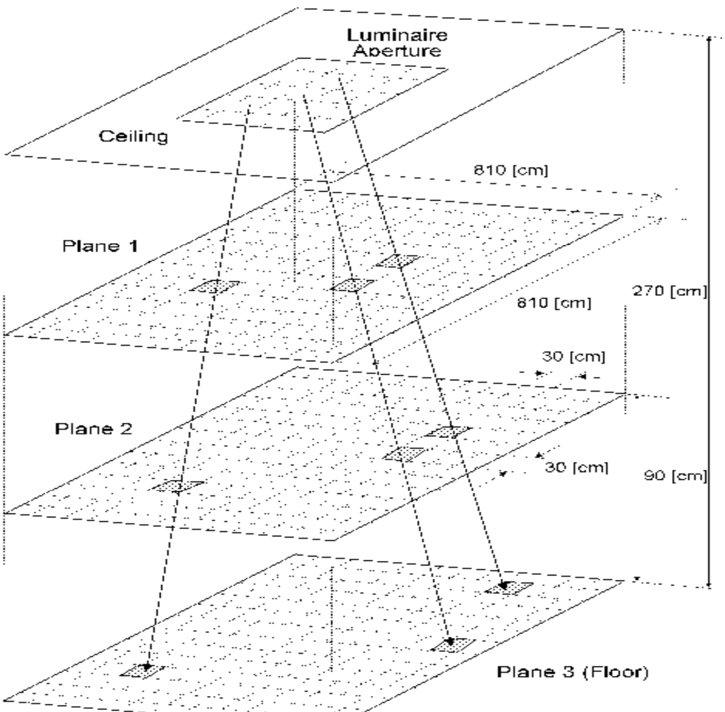

Figure 8 Model of room for flow of light flux and spatial illuminance distribution

8 SPATIAL ILLUMINANCE DISTRIBUTION

The distribution and the variation of the illuminance on every plane in the room space are shown in Figure 9.
The distributions of the spatial illuminance on the planes are different according to the light intensity distribution characteristic of the equipped luminaires.

(1) Batwing Type and Moth Type : The luminous fluxes spread wide and are intense in the AA direction, then the light rays reach extent to the corner on the floor plane in the room and the rays in the centre portion are also considered to be sufficient.

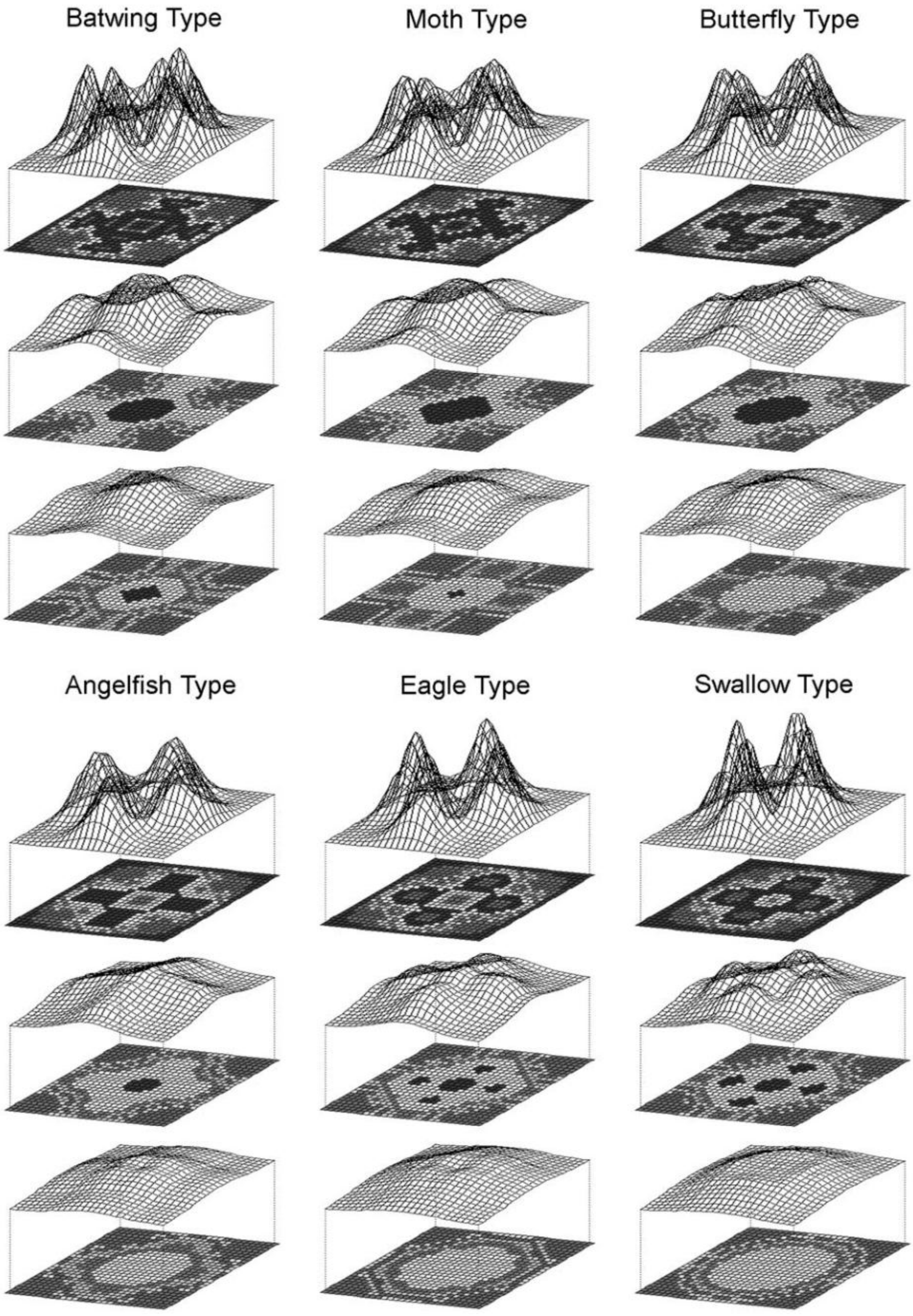

Figure 9 Illuminance distribution at the height of 0, 90 and 180 [cm] from the floor in a room

(2) Butterfly Type and Angelfish Type : The luminous fluxes spread moderately wide in the AA direction, then the light rays reach to the centre on the floor plane and extend to the corner of the room with considerable amount.

(3) Eagle Type and Swallow Type : There are large flows of luminous fluxes in just downward direction, then the spatial illuminance right under the luminaire is extremely high and the illuminance distribution on the working plane is not uniform.

9 CONCLUSION

New algorithm, which is able to analyze non-uniform luminance distribution on lamp surface due to the inter-reflection, has been developed, so that non-uniform luminance distribution, which has been known only experientially, could be evaluated and visualized quantitatively.

As for luminaire reflector whose shape is composed of special curve, luminance distribution on the lamp surface has been estimated. It is confirmed that the luminance increases non-uniformly. Even for special curved reflector like super parabolic curve, which is intended to control precisely light intensity distribution, the luminance increases non-uniformly around about 10%. As for usual luminaire reflector composed of white paint plates, luminance pattern has been also estimated. The luminance increases non-uniformly from 15% to 20%, and the increment of upper part of the tube is evaluated from 3 to 4 times larger as compared to that of the lower part.

By considering non-uniform luminance distribution evaluated by this new algorithm using repeating ray-tracing method, the simulated luminous intensity distribution is well in accord with the measured one. Also the simulated luminous efficiency, that has been difficult to be predicted by traditional simulation method, approaches close to the measured one.

It is necessary that the non-uniform luminance increment on lamp surface is taken into consideration for precise photometric simulation of luminaire reflectors in the case that non-uniform increment of lamp luminance due to the inter-reflection between reflector surface and source surface is not able to be ignored for the precise estimation of luminous intensity distribution.

Some of adequately designed luminaire reflectors are desired to come into practice in the case that the characteristic of light intensity distribution, the efficiency, the quantity of the glare are important matter for the design of comfortable visual environment.

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GLARE SOURCE IN A WINDOW FOR EVALUATING DISCOMFORT GLARE

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ABSTRACT

This work aims to propose a practical method of selecting glare source in a window having non-uniform luminance. Experiments were conducted using a luminous body divided into two parts. Each part of the luminous body has the same size but different luminance. The degree of discomfort glare from the luminous body was investigated. The result shows that the part with lower luminance is not considered as a glare source when the part has luminance less than 49% of the luminance of the higher luminance part.

Keywords: glare, discomfort glare, non-uniform luminance

1 INTRODUCTION

Control of discomfort glare from daylight is an important issue and dominates the quality of daylighting. In general, glare sources of daylight i.e. windows are large and have non-uniform luminous distribution. The sky and the obstacles seen through windows usually have different luminance. Moreover, the luminance distribution of the sky is not uniform [1].

The Unified Glare Rating (UGR)[2] system has been recommended internationally to evaluate the degree of discomfort glare from indoor lighting installations. The UGR system is applied to electric lighting installations, and only a few methods have been investigated for evaluating discomfort glare from windows.

The Daylight Glare Index (DGI)[3] and Predicted Glare Sensation Vote (PGSV) [4] are well known methods to predict discomfort glare from windows. However, these methods are in limited use because these have been developed for evaluating a large glare source with uniform luminance.

In the DGI and PGSV, there is no suggestion about how to determine the luminance of a window having non-uniform luminance distribution. The luminance of a window is a main factor influencing the degree of discomfort glare. When the luminance of a window is defined differently according to the appraisers, the degree of discomfort glare varies widely even in the case of the same window. It is necessary to elucidate the glare source in a window and the method of determining the luminance of the glare source.

This work aims to propose a practical method of selecting glare source and of determining the luminance of glare source in a window having non-uniform luminance.

2 EXPERIMENTAL METHODS

The experiment contained two kinds of measurements: the degree of discomfort glare from the model window with non-uniform luminance is measured, and the ratio of luminance is measured when the observers perceived the difference in luminance.

2.1. Model Windows

A model window was assumed to be a large glare source (Figure 1). The window's size was 90 cm * 90 cm, and white paper was pasted on its surface to produce diffuse light (Figure 2). Sixty-four incandescent lamps were installed inside the window. The luminance of the window can be fixed specifically from a wide range of 0-7400 cd/m^2. The surface of the window was divided into two surfaces, right and left, and the luminance was set differently. The luminance of each surface is controlled by the number of papers pasted on it. The size of the window is controlled by the distance from the eyes of observers to the window. Table 1 shows the experimental conditions.

Table 1 Experimental condition

Luminance of standard part (0.165sr) [cd/m^2]	Luminance of comparative part (0.165sr) [cd/m^2]	Ratio of luminance [-]	Size of window [sr]	Vertical illuminance [lx]
5830	5830	1.00	1.86	9540
5830	5830	1.00	0.68	3820
5830	5830	1.00	0.33	1900
5830	5830	1.00	0.19	1260
5830	5830	1.00	0.12	890
5830	5830	1.00	0.33	610
5830	2540	0.44	0.33	460
5830	1560	0.27	0.33	400
5830	540	0.09	0.33	350
2970	2970	1.00	1.86	1430
2970	2970	1.00	0.68	600
2970	2970	1.00	0.33	290
2970	2970	1.00	0.19	220
2970	2970	1.00	0.12	160
2970	2970	1.00	0.33	290
2970	1790	0.60	0.33	210
2970	1050	0.35	0.33	180
2970	370	0.12	0.33	150

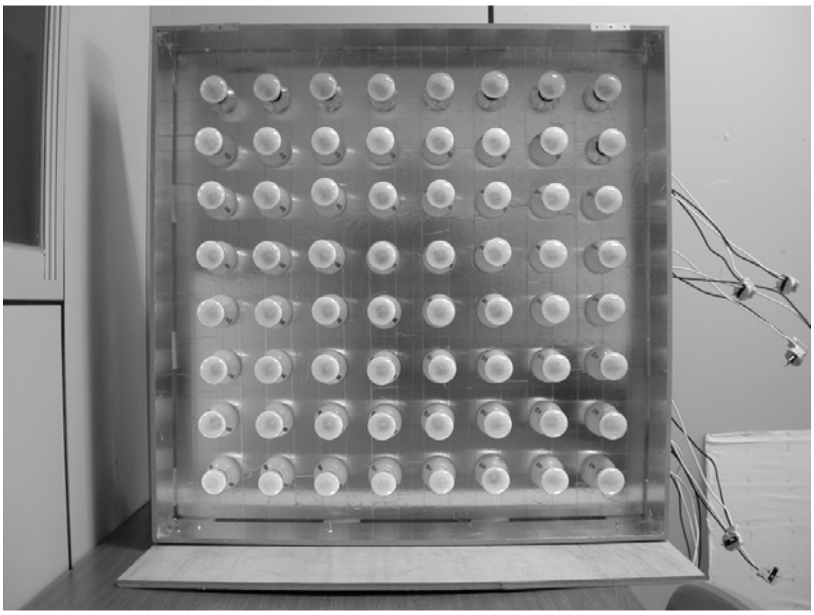

Figure 1 Luminance body for the experiment

Figure 2 Experimental set-up

2.2 Observers' Characteristic
Twenty-one observers volunteered for the experiment. The observers' age ranged from 20 to 40, the average being 25.5. Among them, two observers had contact lenses on during the evaluation.

2.3 Criteria for the Evaluation
The observers evaluated discomfort glare from the window by the multiple criterion scale (Table 3). The degree of discomfort glare is the numerical scale adopted for this experiment.

Table 2 Multiple criterion scale of the evaluation

Degree of discomfort glare	Criterion
4	Just intolerable
3	Just uncomfortable
2	Just acceptable
1	Just perceptible

2.4 Experimental Procedure
The observers were asked to sit on the chair and performed a task of transcribing a book for a minute. After the task, they raised their heads and looked at the center of the window for 5 s, and evaluated the discomfort glare on an evaluation sheet. Each observer repeated the evaluation under the eighteen conditions (Table 1). The different luminance levels were presented randomly so as to control for the effect of presentation. The period of time to complete the evaluation sheet for each observer was 30 min.

3 RESULTS AND DISCUSSION

The relationship between the degree of discomfort glare and the size of the window is represented in Figure 3. The degree of discomfort glare in the Y-axis increases linearly as the size of the window in the Y-axis increases. When the luminance of the window is 5830 cd/m^2, 2970 cd/m^2, the inclination of the regression line in Figure 3 is 1.83, 2.24, respectively. The average inclination is 2.04. This means that the degree of discomfort glare increases by 2.04 when the size of the window increases 1 logarithm. Therefore, it is predicted that the degree of discomfort glare decreases by 0.61 when the size of the window is reduced by half.

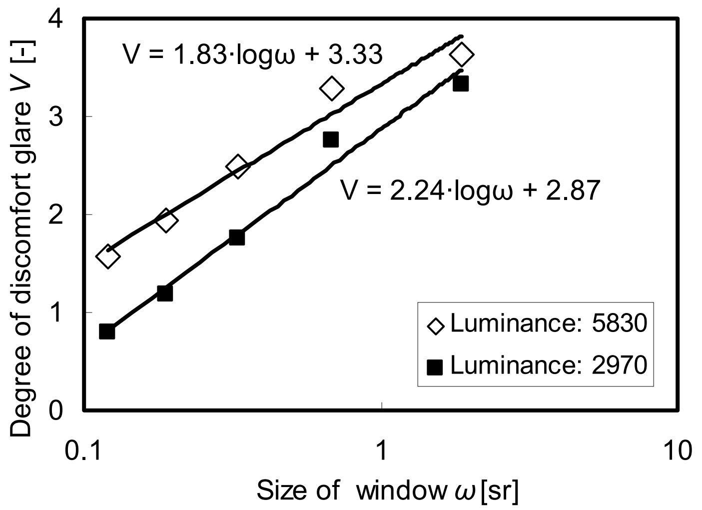

Figure 3 Relationship between the degree of discomfort glare and the size of the window

Figure 4 shows the relationship between the degree of discomfort glare and the ratio of lower luminance to higher luminance in the window. The degree of discomfort glare increases linearly according to the increase of the ratio of luminance.

On the basis that the degree of discomfort glare decreases by 0.61 when the size of the window is reduced by half, it is predicted that the degree of discomfort glare decreases from 2.6 to 1.99 when the size of the window having luminance 5830 cd/m^2 is reduced by half. Also, the degree of discomfort glare decreases from 1.93 to 1.32 when the size of the window having luminance 2970 cd/m^2 reduces by half.

In Figure 4, the ratio of luminance is 0.54 when the degree of discomfort glare is 1.99 on the upper regression line. Also, the ratio of luminance is 0.44 when the degree of discomfort glare is 1.32 on the lower regression line. The average ratio of luminance is 0.49. These results suggest that the part with lower luminance is not considered as a glare source when the part has luminance less than 49% of the luminance of the higher luminance part in the window.

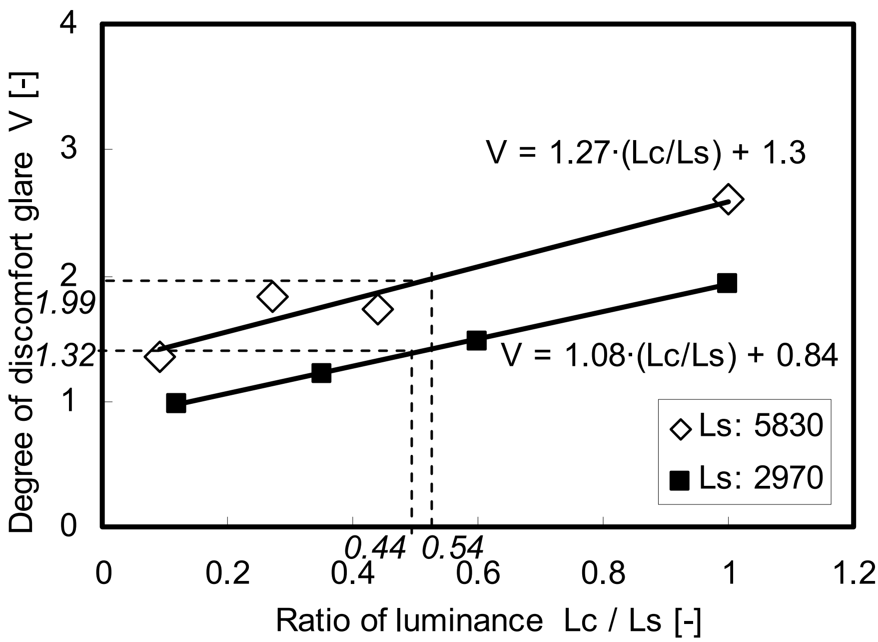

Figure 4 Relationship between the degree of discomfort glare and the ratio of luminance (Ls: higher luminance, Lc: lower luminance)

4 CONCLUSION

From the results in this work, it can be concluded that glare source in a window results from the highest level of luminance down to a level which is 49% of that highest level of luminance.

ACKNOWLEDGEMENTS

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THE EFFECT OF LIGHT SOURCE ON LIGHT POLLUTION IN GAS STATIONS

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ABSTRACT

There is increasing concern for the unwanted light pollution created by gas station lighting. However, standard for light pollution has not been prepared in Korea. It is consequence that gas station lighting designers should recognize the need to control problems related to the light pollution of gas station. This study aims to analyze the light pollution of gas station according to the 3 types light source: cutoff, non-cutoff and full-cutoff. Luminance of gas station façade, sign board, color temperature, and chromaticity were measured. Radiant Imaging Prometric-1400 and MINOLTA CS-100 were used and compared with CIE recommendations. The evaluation was carried out between January 21 and April 4, 2007. Non-cutoff lighting has occurred severe light pollution. However, the luminance of the sign board is suitable for CIE recommendation level. Korea has not yet provided proper regulations or guidelines for the control of light pollution, it is necessary to take appropriate measures for it.

Keywords: light source, light pollution, gas station, outdoor lighting, luminance

1 INTRODUCTION

If one gas station in an area installs lighting with greater brightness, competing stations feel obliged to be brighter still [1]. It means, the gas stations have excessive outdoor lighting for the competitiveness with others stations. It affects substantial problems, including glare for drivers, pedestrians, visual chaos, waste of energy, damage of surrounding environment.

Three gas stations with different light source, in full-cutoff, cutoff and non-cutoff, were selected. Prometric-1400, CS-100, and digital camera were used to measure. Luminance of building surface, and sign boards, chromaticity, and color temperature were measured and analyzed.

2 GAS STATIONS

Figure 1 shows the location of the gas stations, between a factory and unused building site. Three gas stations are located in the 25m-width roadside. Roadway lamps are installed at intervals of 14 ~ 16 m on the border of the roadway. The frequency of vehicles are very heavy during the day and night. Each gas station has its own identified lighting facility by the guideline of the company. All of the gas stations have is halogen lamps

The architectural characteristics of three gas stations are as follows.

- Structures : Steel Structures
- Gas stand : 8 gas stands
- Wall : Aluminium panel, Ceramic tile
- Ceiling : Color aluminium
- Facilities : Convenience store
- Floor : Reinforced concrete with Hardener

Figure 1 Photographs of the Gas stations

3 MEASUREMENT AND RESULTS

CIE recommends classifies environmental areas into four classes to evaluate light pollution and suggests the luminance of building facades and recommended illuminance levels according to each class [2]. This area is as E3 class, according to the CIE classification, with medium luminance and industrial-residential area.

Three different canopy lighting installations were evaluated. Pilot measurements were taken on January 21, 2007, and main measurements were taken during the period from March 25 to April 4, 2007. And a variety of photometric measures were taken after 8:00 p.m. The measurement equipment was used the Radiant Imaging Prometric-1400, CS-100 luminance meter, and two digital cameras. There were 4 to 5 people involved in taking measurements.

They were taken from locations, 20 meters distanced from the façade of each gas station. The measuring points for each gas station are ceiling and column of the canopy, ground under canopy, signboard, and background sky. The measurement of the light source could be analyzed with the side, not point, with the instruments of Prometric-1400 that the entire ceiling including the light source was analyzed.

A short summary of the characteristics of the three type lighting, cutoff, non-cutoff and full-cutoff is given in Table 1.

Table 1 Lighting of the Gas Stations

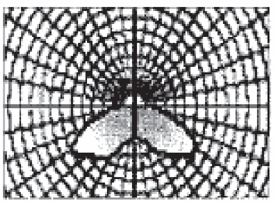
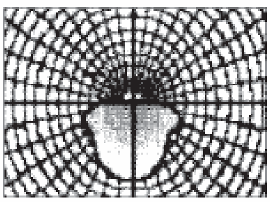
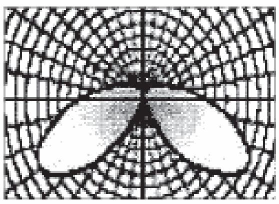
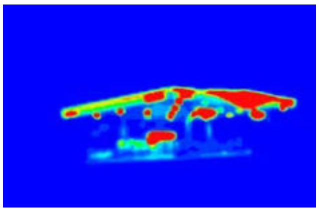
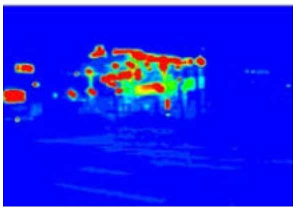
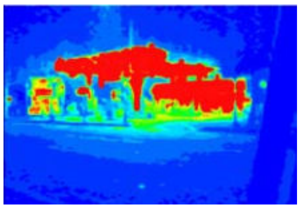
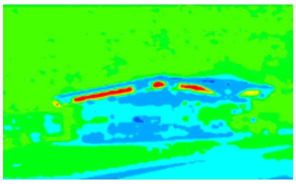
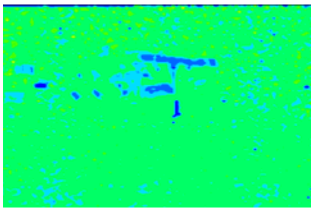
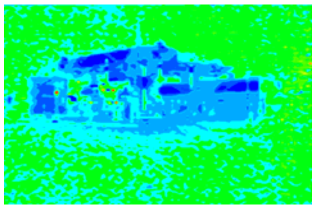
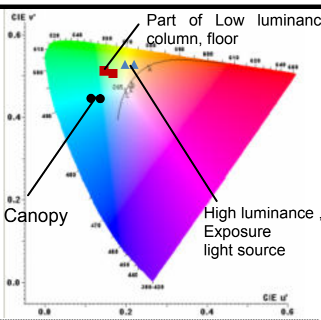
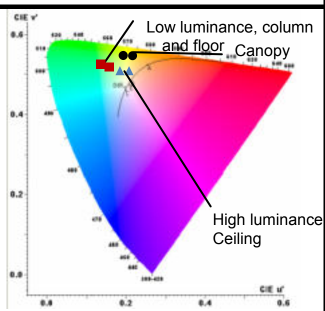
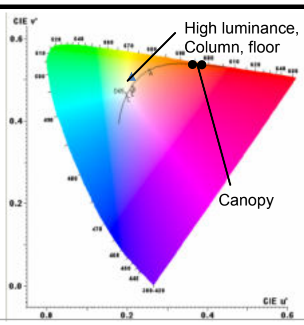
	Full-Cutoff	**Cutoff**	**Non-Cutoff**
Day Scene			
Night Scene			
Luminaires Characteristics [5]	- A luminaire light distribution where zero candela intensity occurs at or above an angle of 90° up from nadir.	- A luminaire light distribution where the candela per 1000 lamp lumens does not numerically exceed 25 (2-1/2%) at or above a vertical angle of 90° up from nadir, and 100 (10%) at or above a vertical angle of 80° up from nadir	- A luminaire light distribution where there is no candela limitation in the zone above or below the beam of maximum candelas
Quantity of Luminaires	18	10	8
Above an angle	0%	0%-5%	0%-20%
Distribution curve of luminous intensity			

Table 2 Results of the measurements

	Full-Cutoff	**Cutoff**	**Non-Cutoff**
Luminance			
CIE recommendations	Building Surfaces : 10[cd/m²] Advertising Sing Surfaces : 800[cd/m²]		
Ceiling	**11.2[cd/m²]**	**152.0[cd/m²]**	**233.0[cd/m²]**
Column	4.5[cd/m²]	**15.3[cd/m²]**	**67.6[cd/m²]**
Floor	5.3[cd/m²]	**11.9[cd/m²]**	**53.2[cd/m²]**
Signboard	64.0[cd/m²]	67.0[cd/m²]	95.0[cd/m²]
Background	0.5[cd/m²]	0.6[cd/m²]	1.0[cd/m²]
Analysis	- Only Ceiling luminance was 12% higher than the standard	- Ceiling, column and floor were 15times, 1.5times and 1.2times higher than the standard	- Ceiling, column and floor were 23times, 6.7times and 5.3times higher than the standard
	- Signboard luminance is suitable for CIE recommended level		
Color temperature			
Column, Floor	4,935[k]	4,938[k]	4,295[k]
Ceiling	4,626[k]	3,591[k]	2,670[k]
Signboard	5,029[k]	4,300[k]	3,734[k]
Average	4,916[k]	4,620[k]	3,643[k]
Analysis	- building surface, signboard appeared cold image	- Column, floor, signboard appeared as cold image - the lighting of the ceiling appeared as stable and soft	- Column, floor, appeared as cold image - Ceiling and signboard appeared as warm
Chromaticity			
	- Hyundai oil bank Co., Ltd. color is blue circle on the ground stands for the infinite blue earth, and the green formation, which shines as a Light of Hope.	- The purpose of S-OIL company is to use the raw color of yellow to produce the familiar and dynamic image.	- The purpose of SK corporation is to use the red line of colors to produce the dynamic and active image.
	As a result of the analysis, it was consistent to the purpose of the company.		

4 CONCLUSION

This study analyzed the luminance, color temperature and chromaticity of illuminated three company gas stations with three different light sources, which are representative of Korea. The results of the measurements can be summarized as follows:

(1) Average luminance of the gas station with non-cutoff luminaries was 10 times higher than that with full-cutoff luminaries. The other side, all gas station signboard luminance are lower than the CIE recommendation of 800cd/㎡. The façade lighting in more brighten than signboard lighting.

(2) In color temperature of the surfaces including column, ceiling, ground and signboard, the average level of full-cutoff is 4,916 [k], cutoff 4,620 [k], and non-cutoff 3,643 [k]. The non-cutoff appeared as more warm than full-cutoff.

(3) Chromaticity, canopy lighting, sign boards and the logo was the image of the company's colors system.

The amount of light trespass was perceived by the gas station lighting. It is necessary to research the psychological aspects of light pollution and provide proper outdoor lighting standards.

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MICROPROCESSOR CONTROLED ELECTRONIC BALLASTS FOR HID LAMPS. METROLIGHT CASE STUDY

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ABSTRACT

This paper presents the main characteristics of the modern electronic ballasts for HID lamps vs. the magnetic ones and exemplifies with a smart digital high-frequency controller produced by Metrolight. The special microprocessor strategy, the high frequency square wave pulses and optimal adaptation to the lamp lead to very high performances in terms of efficiency, lamp life, energy and cost savings etc. Finally, analyzing a Metrolight's ballasts application, an economic analysis and saving estimation is presented.

1 INTRODUCTION

High-Intensity-Discharge (HID) lamps are widely used in outdoor and indoor applications. Their attractive features include high light efficiency, good color rendering, low cost due to long maintenance intervals and long lifetime. In principle, the use of high frequency electronic ballast can reduce the size and the weight of the ballast equipment and improve the system efficacy.

For high-frequency operating circuit used in the HID lamp such as high-pressure mercury lamps and metal halide lamps, high barriers of acoustic resonance phenomena and higher costs hindered realization of computerized ballast. Therefore, magnetic circuit type operating circuits were used extensively even today.

Nowadays, many research centers are dedicated to develop light, compact, efficient electronic ballasts with high power factor, and particularly with low cost. However, almost all these efforts have been focused to high-pressure lamps, such as mainly metal halide lamps and high-pressure sodium lamps. This is mainly due to two reasons: firstly, the lower number of HID lamp appliances types, and secondly, the more critical operation characteristics of this type of lamps.

There are two factors to be considered. One is how to design the electronic ballast architecture such as volume, weight and circuit topology, the other is how to match electronic ballasts and lamps with high efficiency, high stability and long lamp life.

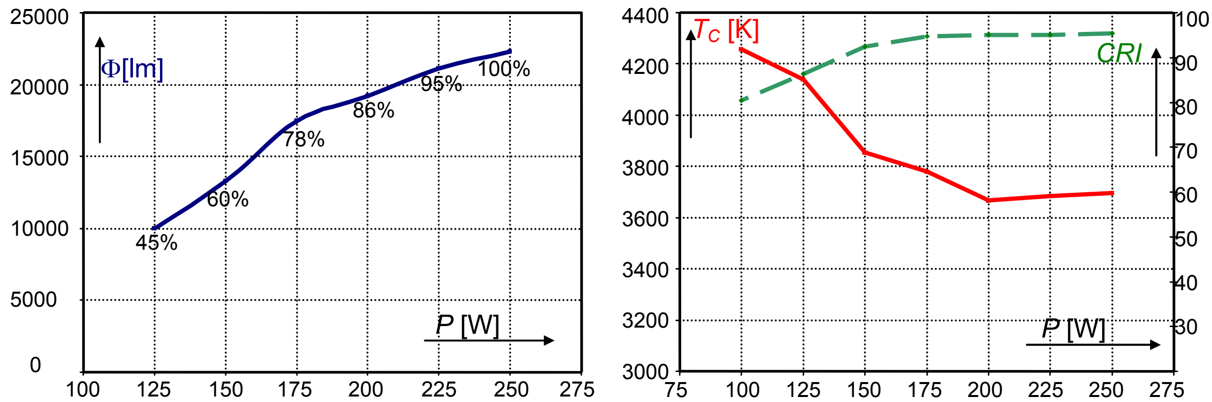
The usual requested properties and function for ballasts are: high power factor (>0.96), low current harmonic distortion (<5%), output efficiency of the ballast is higher than 0.9, complete protection ability (much more safe) and to be able to drive several types of HID light sources as MH lamps, ultra high performance (UHP) lamps, high-pressure sodium (HPS) lamps, and automobile headlamps, etc. New generation electronic ballast controllers include some useful functions such as soft starting, lamp fault protection, power control for dimming, overload protection, real-time acoustic resonance detection, and a great capacity of communication and remote control, like Metrolight does with his MALDI/DALI protocol and control software.

2 DIMMING CONTROL

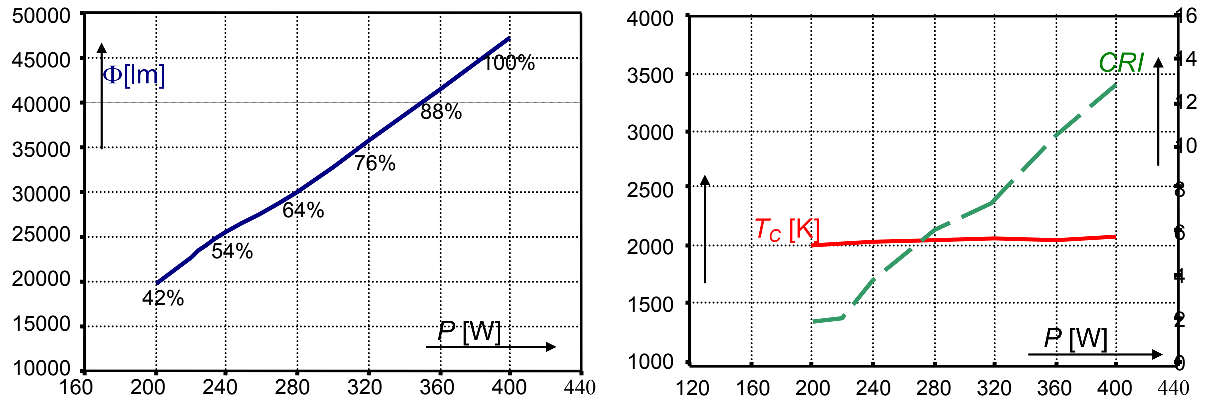
The most usual dimming control methods are the frequency control and voltage control methods, which have been previously examined for low-pressure fluorescent lamps. Experiments and analysis indicate that the two dimming methods have their respective advantages and disadvantages. If the right dimming methods and ballast structures are combined properly, good dimming control for HID lamps at high frequency operation can be achieved.

In [8] experiments haven been analyzed on small-wattage metal halide lamps to investigate the effects of the operating frequency and the lamp power on spectral power distribution, luminous efficiency, and acoustic resonance. It is shown that the spectral power distributions remain the same with the changes in the operating frequency but significantly affected by the lamp power, and the luminous efficiency decreases slightly as the operating frequency increases but deteriorates considerably as the lamp power is reduced.

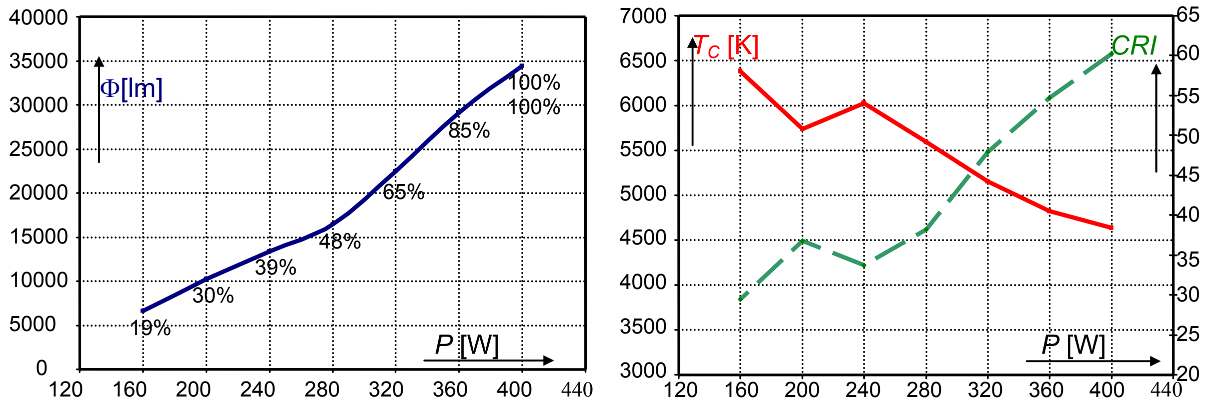
Other experiments done by Metrolight with the own microprocessor-driven HF electronic ballast show (Figure 1) that a dimming range from 100% to at least 45% up to 19% can be achieved, depending on the HID lamp type. Comparing with magnetic ballasts, dimming with electronic ballasts is much more linear, yielding greater energy savings.



400W HPS lamp



250W CDM lamp



400W MH lamp

Figure 1 Lighting flux Φ, color temperature T_C and color rendering index *CRI* variations with power diminution (source: Metrolight)

3 EXTEND OF LAMP LIFE

The rate lamp life for pulse-start MH lamps, for example, typically ranges from 12000 to 20000 hours, while MH ballasts have a longer life, generally around 60000 hours.

The lamp life depends on many factors but first on the operating conditions. The Figures 2 and 3 highlighted a chain reaction of the negative phenomenon's that affect the lamps. The overheating of the electrodes because of the high ignition voltage pulses, or because of the LF sine wave supply during long stable arc operation results in erosion of the electrodes and metal splats. These are spread to the lamp walls causing the so-called "wall blackening effect". The lower wall transparence involves the increase of the envelope temperature and accelerates the gas leakage. In the same time, the lamp efficiency dramatically decreases.

The Metrolight electronic ballast avoids these side effects through a microprocessor controlled ignition and operation, using very high-frequency square-wave pulses of about 20MHz both at ignition and operation. More, these are modulated depending on the controlled periods of ignition, warm-up and working (Figure 4).

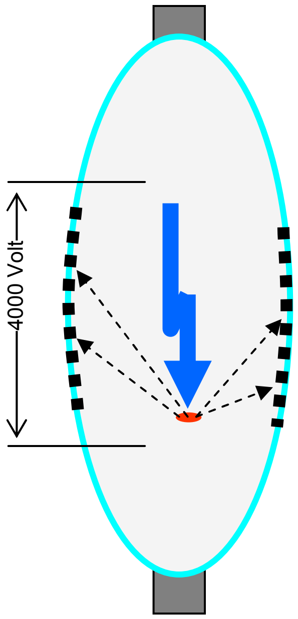


Figure 2 Metal splats on the burner walls at ignition causes walls blackening effect

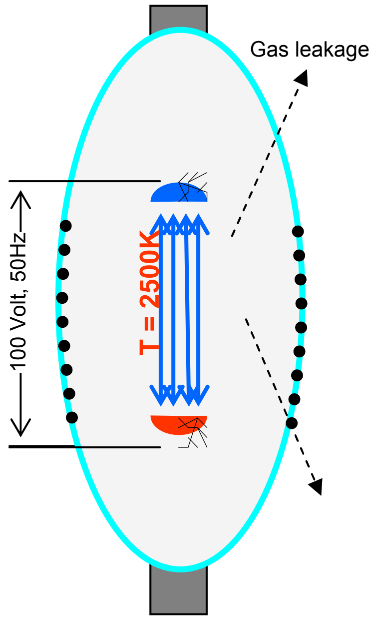


Figure 3 During stable-arc operation, the LF sine wave causes drastic temperature changes and results in further erosion of electrodes

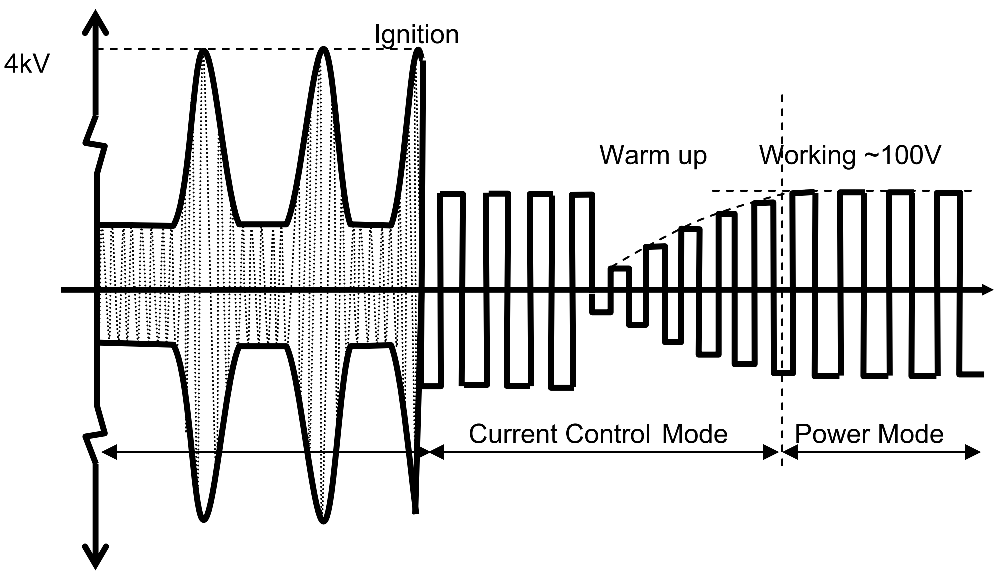


Figure 4 Microprocessor controlled process of ignition, warm up and normal operation

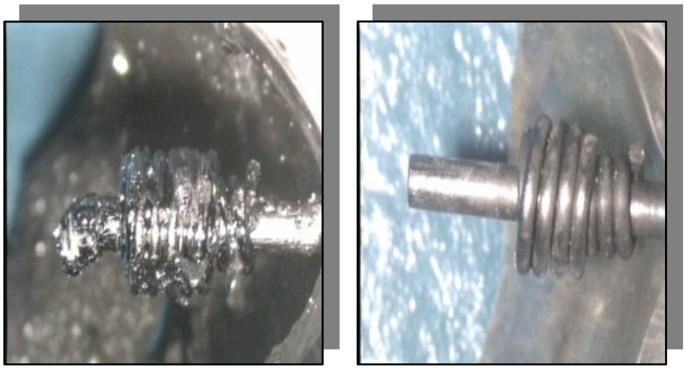
The used control strategy leads to important benefits like an dramatically extended lamp life up to 300%, and a quasi-constant maintaining over the entire operation period of the luminous parameters as lighting flux, color rendering etc. Very suggestive are the views presented in Figures 5 and 6 of the tungsten electrodes of a MH lamp after 8000 hours of working.

4 ACOUSTIC RESONANCE

Conventional magnetic or electronic ballast

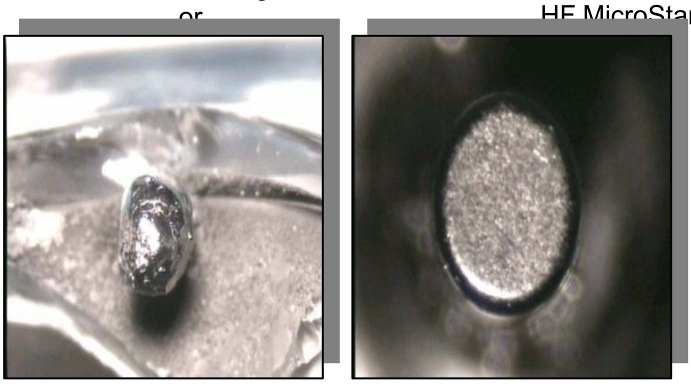
Metrolight electronic ballast with High Frequency MicroStart™ Ignition

Figure 5 Discharge tube view of a 400W Metal-Halide lamp after 8000 operating hours



Side view - Conventional magnetic or

Side view - Metrolight electronic ballast with HF MicroStart™ Ignition



Top view - Conventional magnetic electronic ballast

Top view - Metrolight electronic ballast with HF MicroSta

Figure 6 Views of the tungsten electrodes of a 40(Metal-Halide lamp after 8000 working hours

One major limitation of high frequency operation of the electronic ballasts is considered the acoustic resonance problem. Periodic excitation of the lamp at high frequency can lead to acoustic resonance that in turn cause unstable arc or even extinction of the lamp arc. The problem of acoustic resonances is characteristic of the HID lamps operating at frequencies greater than about 10 kHz and they appear when the modulation of the power in the lamp exceeds a threshold value [6]. Some of the problems that this phenomenon causes are: fluctuation of the emitted light, variation of the color temperature, variation of lamp voltage and, in the worst case, rupture of the discharge tube. This phenomenon depends also on the gas pressure inside the discharge tube, the geometric characteristics of the discharge volume and the temperature of the filling gas.

As a consequence, the frequency range within which the acoustic resonances appear varies with the type of lamp. However, thanks to the advantages provided by electronic ballast for HID lamps, several solutions to the problem of acoustic resonances have been proposed. All of them are based in the same principle: to avoid that the lamp reaches a combination of power and frequency that would exceed the threshold value producing acoustic resonance. Some of the proposed solutions are the following: operation inside a frequency range free of acoustic resonances (22-28 kHz, 300-400 kHz and >1 MHz), supply the lamp with a current square waveform at low frequency, modulation of the switching frequency, application of a non-sinusoidal voltage in the lamp, phase angle modulation, phase angle modulation with random noise generation.

However, the application of a perfect square current waveform to the lamp represents a universal solution to the problem of acoustic resonances. Metrolight combine the square current waveform with the very high-frequency (over 1 MHz) to get the stable and resonance free operation.

5 COMMUNICATION AND CONTROL

The limited length of paper doesn't allow developing another important advantage of the Metrolight Super HID Electronic Ballast, which consists in the great capacity of communication and remote control. Different communication protocols can be used, like RF, PLC, DALI or the Metrolight's MALDI. With a single MALDI control box up to 1023 ballasts can be controlled.

6 SAVING COSTS

As mentioned above, the higher cost of the digital electronic ballast was the main impediment in their expansion. But the technological progresses, lowered prices, indubitable advantages and energy efficiency requirements have change the HID lamps powering options.
Using Metrolight Super HID Electronic Ballasts the costs savings results, as illustrated in Figure 7, from the greater efficiency and dimming capability of the lamp-ballast assembly that lead to savings in energy consumption, but also from the lower maintenance and re-lamping costs.
The IKEA center in Netanya, Israel has a display area of over 44,000 square feet, illumination of which

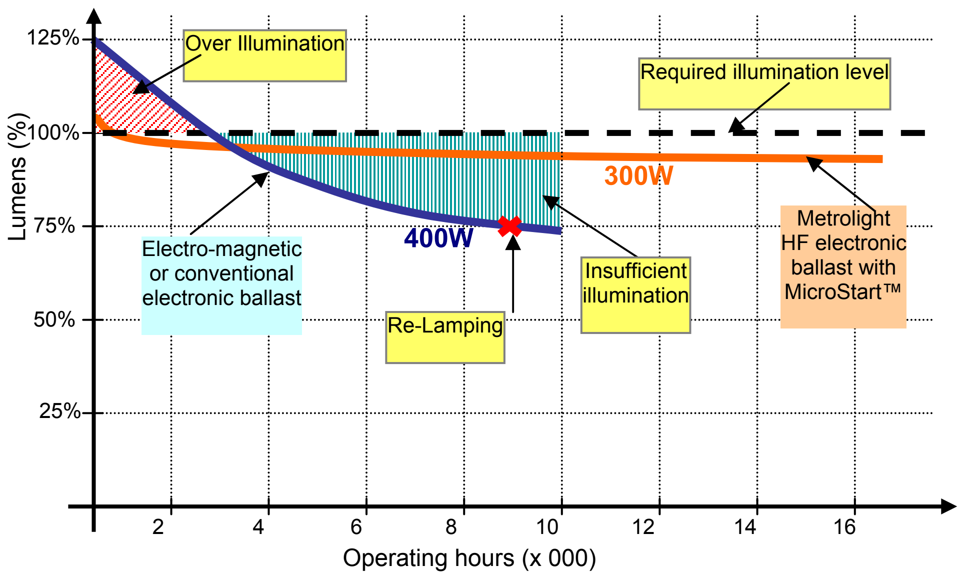


Figure 7 Extend of lamp life & Lumens maintenance with Metrolight Super HID Electronic Ballast

is provided by 400W Metal-Halide lamps. IKEA management selected the Metrolight SuperHID solution to increase the average illumination whereby reducing maintenance and saving energy.

The Metrolight solution included: 400W SuperHID Electronic Ballasts dimmed to 300W level all connected to a central MetroControl™ computer.

Table 1 presents the saving analysis done for this application, taking into account re-lamping every two years with magnetic ballast and five years with Super HID.

Table 1 (Source: Metrolight)

	Magnetic	**SuperHID**
Number of lamps	190	190
Lamp wattage / Setup	400W	300W
Ballast type	Magnetic	SuperHID-300
Light output (lux)	90 lux	200 lux
Price per KWH	$0.13	$0.13
Annual power consumption, KWh	329,639	220,645
Annual cost (US$)	$42,853	$28,684
10 years maintenance cost (1) (US$)	$20,520	$10,944
Total 10 years cost (US$)	$449,050	$297,782
Total 10 years saving		**$151,267**

7. CONCLUSIONS

The high performances of the Metrolight microprocessor electronic ballast as tremendous energy saving (up to 65%), high efficiency (95% lumen maintenance), high power-factor (98%), universal input voltage (90-305 VAC), microprocessor controlled soft start, dramatic extension of lamp life (250-300), hot re-strike ignition for HPS lamps, automatic protection etc, represent the best argument in surpassing the apparent higher initial cost of this kind of ballasts.

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SOLID-STATE LIGHTING SYSTEMS- GUIDELINES FOR STANDARS IN DOMESTIC AND INDUSTRIAL APPLICATIONS

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ABSTRACT

The omnipresence of Solid-State Lighting will drive the development of new low-voltage electrical distribution standards for buildings. Solid-State Lighting differs fundamentally from traditional lighting technologies in terms of materials, drivers, system architecture, controls, and photometric properties. A multitude of new standards, norms and test procedures is needed to accommodate these technical differences. The authors analyze briefly the technological status of the SSL with LEDs, and presents arguments for the use of these lighting systems, assisting in re-thinking to conceptualise new ways of lighting. Ultimately, examines the lighting and electrical standards, norms or recommendations, and offer specific guidelines for SSL standards in domestic and industrial applications.

1 INTRODUCTION

Solid-state lighting differs fundamentally from traditional lighting technologies in terms of materials, drivers, system architecture, controls, and photometric properties. A multitude of new standards, norms and test procedures is needed to accommodate these technical differences.

Standards for SSL systems are necessary, in general, because:

- enable products or components to work interchangeably or together;
- provide assurance that the product can deliver a certain level of performance; and
- provide the tools (symbols, terminology, methodology, etc) that make it easier for designers, manufacturers and users to communicate.

Despite continual improvements in the field of semiconductor lighting, the absence of a consistent standardization may possibly obstruct the LED's success in the lighting community.
Since performance measurements are not yet reliable and consistent, there is great concerned that solid-state technology will only be chosen for applications where the advantages are obvious and the higher cost can clearly be justified.

The most important information about Solid-State lighting with LEDs includes:

- Accurate and reliable figures for the actual light output and efficiency of an installed system, as well as for individual LEDs.
- A realistic estimate of LED life. Long lifetime is publicized as one of the key benefits of LED technology, but there is no standard definition of LED life.
- An understanding of the colour characteristics of LEDs. One of the most controversial metrics is the colour-rendering index (CRI), which is meant to provide a measure of colour quality but is recognized to have several limitations, particularly for LEDs.
- A comprehensive assessment of any safety or installation issues. No safety standards are currently dedicated to LED light sources.
- A realistic estimate of the cost associated with deploying a particular lighting solution. The standard cost-per-lumen figure only measures the initial installation costs, while alternative "cost-of-light" metrics take account of the reduced running costs enabled by LEDs' longer lifetime and reduced energy consumption.

2 DEVELOPMENT OF STANDARS FOR MEASURING LED's PROPERTIES

In general, Standard techniques for optical radiation measurements are developed by the Commission Internationale de l'Eclairage (CIE), (the International Commission on Illumination). The issues of LED measurements were raised several years ago, and in 1997, CIE to introduce a new quantity for their characterization with precisely defined measurement conditions.

The new quantity has been given the name "Averaged LED Intensity". It can be used to provide meaningful and reproducible data for many of the different types of LEDs now on the market. The evaluation of the luminous flux must be carried out with caution, utilizing specially constructed integrating spheres. Best results will be obtained if luminous intensity and luminous flux are measured by a comparison method and every laboratory should have available a standard, temperature controlled and calibrated LED with the same spectral and spatial power distribution as the test LEDs to allow measurements to be made on this basis.

Spectroradiometric measurements can be performed using the same technique as for other light sources with careful alignment along the optical axis.

2.1 Luminous intensity

Luminous intensity is a quantity that strictly describes a point source and most LEDs are not point sources at close distances; therefore the measured luminous intensity varies depending on the distance and size of the photometer aperture. To solve this problem, have been introduced standardized geometries: the size of the photometer aperture is 1 cm^2 (circular), and the distance between the LED and the photometer is 316 mm or 100 mm (Figure 1). These fixed geometries have made the measurements reproducible and comparable. The quantity measured is not a true luminous intensity. These fixed geometries have made the measurements reproducible and comparable.

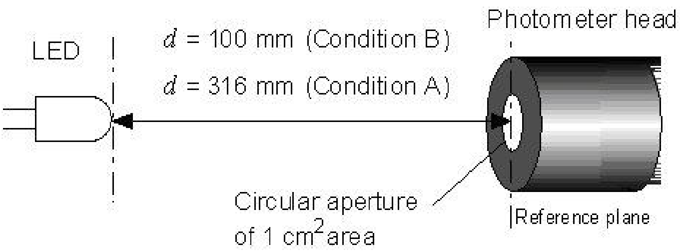

Figure 1 Standardized geometries for LED measurement

2.2 Partial LED Flux (flux emitted within a given cone angle)

This property is defined as the flux leaving the LED and propagating within a given cone angle, centred from the LED's mechanical axis. Any flux emitted in the directions other than in this cone angle is ignored. Such a quantity is considered because, in many applications, the flux emitted only in the forward direction is used, and such partial flux (without backward emission) needs to be evaluated. Recently, spectroradiometers are increasingly being used for LED measurements not only for measurement of colour but also for luminous intensity and luminous flux of LEDs. Obviously many questions and concerns still exist in the measurement of LED clusters and arrays.

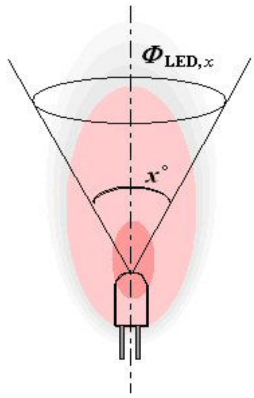

Figure 2 Partial LED flux

2.3 Colour Rendering of White LED Light Sources

The CRI even after a few revisions, it still uses outdated formulae and methods, and it is known to have deficiencies. The problem is prominent with narrow-band sources, and the use of CRI for RGB white LEDs or multi-chip white LEDs can mislead design directions. These problems are under investigation at many lighting laboratories and institutes, and improvement of CRI or different new methods, particularly for solid-state lighting sources, are being studied.

2.4 Measurement of LED Radiance and Luminance

One aspect that makes the evaluation difficult is the measurement of radiance of LEDs, which is the quantity that relates to the level of injury. However, due to small size and very directional characteristics of LEDs, measurement of radiance is very difficult and a large uncertainty is involved. Also, there is an effect that, if the size of the source is very small, the effective source will be larger (thus effective luminance will reduce) due to small eye movement.

2.5 RoHS compliance

The Restriction of Hazardous Substances (RoHS) compliance as the latest in a long-standing commitment to industry standards is critical to the adoption of LED lighting. The RoHS environmental directive calls for the restriction of certain hazardous substances in electrical and electronic equipment sold into the European market. Commonly-used lead-tin solder has had to be replaced with higher-melting-point alternatives.

3 KEY METRICS FOR SOLID-STATE LIGHTING

There are a wide variety of metrics used in lighting, especially those related to general illumination, is now becoming possible with solid-state devices. In general, SI units are the preferred dimensions of all official units but lighting, like a few other industries, are still using few traditional units. For SSL systems with LED following metrics described as below are presently used.

3.1 Luminous efficacy- Lumens per watt

The output of an LED consists of light and heat. Measuring the amount of light can take two forms: radiometric and photometric. A radiometric measurement gives the true optical power as determined by total energy across the spectrum of the light source. The performance of an LED is often considered as the ratio of the output radiant power (in watts) to input electrical (in watts) - this ratio is the radiant efficiency.

Luminous efficacy of a source is the ratio of lumens (total luminous flux) to watts (total electrical power input). The term efficacy is not the same as efficiency. Efficiency, more specifically radiant efficiency as defined above, is a dimensionless quantity, which is usually expressed as a percentage. However, luminous efficacy of radiation is the ratio of luminous flux to radiant power, which is a theoretical maximum that a light source with a given spectral distribution can achieve with a 100% radiant efficiency.

3.2 Cost per lumen

Measure the total number of lumens of the LED light source divided by the total cost for the light source. This gives a metric that is a measure of how much light, or flux, is available per economic unit. It is a measure of direct cost of a LED light source and which is continuously decreasing (in the future it will probably specify in dollars per mega-lumen).

3.3 Lumen-hours

This is the photometric equivalent of the watt-hour (or kW-hour), with both being the product of power and time. Since power is energy/time, the lumen-hour measures energy. Due to the large quantities involved is often expressed in million lumen-hours or even mega lumen-hours.

3.4 Cost per million lumen-hours

While a seemingly an odd metric, this has parallels to the monthly (electric) cost paid for that lighting system. A way to calculate the cost of a light source over time, incorporates lifetime, power consumption and initial cost.

3.5 Colour temperature

Colour temperature by itself isn't a metric of performance. It's typically a specification of the type of a LED light source, and is used to describe the colour of white light. Colour temperature is a generally accepted means of describing the colour of white light and is measured on an absolute temperature scale, in degrees Kelvin.

3.6 Colour Rendering Index (CRI)

Is often quoted to indicate how accurately that LED light will portray colours relative to a blackbody source at the same nominal colour temperature. By definition, all blackbody sources have a CRI of 100.

3.7 Correlated colour temperature (CCT)

Correlated colour temperature refers to the closest point on the black body curve to a particular colour as defined by its chromaticity value. According to the CIE, chromaticity values that are further than 0.05 from the black body curve are simply colours and not a CCT.

4 LIGHT OUTPUT MAINTENANCE (LED LIFE)

Despite continual improvements in LED brightness, colour and efficacy, one problem remain that could impede the LED’s success in the lighting community: the absence of a consistent definition of life. Rather than experiencing a complete operational failure, LED light output slowly decreases with time.

The lamp life based on lumen maintenance criteria is relatively uncommon, but re-lamping at the end of useful life rather than rated life is not uncommon.

The Light output maintenance describes the (time) period in which a SSL source provides a predictable (acceptable) light level and colour shift for a given application. In defining this period of useful life, it is recommended to use lumen maintenance values, or how a lamp maintains its light output over its lifetime.

LED life is related to junction temperature, which difficult to measure, especially once LED dies are packaged into their housing. A reasonable estimate can be made by measuring the temperature where the LED is soldered to the circuit board. Because it can be measured more conveniently it is recommended for component life measurements because has a similar relationship to life as the junction temperature.

Component life measurements should be taken at four different temperatures as follows:

a. 45 °C and 55 °C for those operating below 100 mA
b. 65 °C and 85 °C for those operating above 100 mA

Different temperatures can be achieved either by changing the current or by changing the ambient temperature of the testing space.

For measuring both components and systems, a minimum operating period of 6000 hours (250 days) at rated current and voltage. The first 1000 hours is an initial seasoning period for the LEDs, and the next 5000 hours is for actual light output measurement.

Light output data collected between 1000 and 6000 hours is used to measure or estimate the time needed to reach 80% and respectively 50% lumen maintenance. It is recommended 4 levels of lumen maintenance as the basis of determining the end of useful life for an LED light source. A lumen maintenance of 50% is to be considered the less stringent requirement and the bottom of the rank for application such as a decorative lighting and eventually emergency lighting. Next levels to be considered are 60%, 70% and respectively 80% where uniform appearance and system efficiency are the most stringent.

This may well create a consistency in life estimation and data reporting methods which will establish a realistic life expectancy for LED lighting products, and comparisons among lighting products. Second, the measurement and extrapolation guidelines will ensure that all LED lighting manufacturers test their products in a similar manner.

5 SSL SYSTEM APPLICATION EFFICACY

For peripheral viewing under mesopic conditions, lamp efficacy is different than it is for photopic conditions. This phenomenon lead to the fact the lamp efficacy is not necessarily the same as system, or luminaire, efficacy. For example, in architectural lighting, at least qualitatively, the luminaire efficacy is only partially related to lamp efficacy. Or to be precise, it is difficult to create narrow distributions with fluorescent lamp systems using small luminaires.

The purpose of this paper is to suggest that the efficacy of Solid-State lighting applications is based upon, the LED lamp and the luminaire (as a system) rather than, solely on LED lamp efficacy. More importantly perhaps, is specifically delivering light where it is needed in the most energy efficient manner. The term application efficacy is a practical measure that helps ensure that the most energy efficient luminaire will be employed for a given application. It will also be shown that the most efficacious lamp is not always associated with the most efficacious luminaire for a given application.

5.1 LED lamp luminous efficacy

LED Lamp efficacy (Le) is a measure of how much light, in lumens (lm), the LED lamp generates per unit power, in watts (W), supplied to that lamp. The total lumens generated by the LED lamp are measured, irrespective of the direction that they are emitted, and this quantity is divided by the total wattage needed to operate the lamp.

Like lamp efficacy, SSL luminaire luminous efficacy is a measure of the total lumens emitted by the entire system per unit power. This measurement is obtained from measurements or estimates of the efficiencies of each luminaire component such as step down converter, driver, controlling system, etc.

The ability of the luminaire to deliver light in a particular direction and within a particular distribution is very important to characterize the efficiency lighting application. An intensity distribution from a photometric report does not, readily give a sense of the efficacy with which the luminaire can deliver light to a location. The relationship between the light distribution of the luminaire and its ability to effectively deliver the light to a location is addressed by application efficacy.

5.2 Application efficacy

Application efficacy is defined for a SSL-LED luminaire, or a LED lamp used as a luminaire, as the average luminous flux within a specific solid angle per unit power. It is measured in lumens (lm) per steradian (sr), or intensity (in candelas, cd), per watt (W). A simple mathematical identity relates application efficacy (Ae) to luminous efficacy (Le). By definition,

$$Le = \text{luminous flux/power} \ (\text{lm/W}) \tag{1}$$

where luminous flux is measured in lumens (lm) and power is measured in watts (W). Since:

$$Le/\Omega = \text{luminous intensity/power} \ (\text{cd/W}) \tag{2}$$

because luminous intensity in a specific direction is measured in candelas (cd), which correspond to luminous flux (lm) per solid angle (Ω, measured in steradians sr). Ae is the ratio of the lumens within the solid angle of interest (or intensity) to the power required to generate those lumens; therefore,

$$Ae = Le/\Omega \tag{3}$$

Ae is dependent upon the solid angle of interest, so the intensity value in the numerator is dependent upon a specified solid angle. Then the effectiveness of a luminaire needs to be quantified with respect to the area needed to be illuminated, not with respect to the Le of the luminaire (nor simply the lamp inside the luminaire). A successful lighting application must have light delivered where it is needed; light absorbed by the luminaire ant/light directed to areas other than intended is wasted. The key to energy efficiency is to understanding where the light is placed (and with controls, when it is applied). The locations for light delivery can be best characterized in terms of direction and solid angle with respect to the luminaire. Ae can be defined for any solid angle and for any number of luminaires by defining the area to be illuminated and summing the luminous flux delivered to that area. Luminous flux delivered to areas outside the defined area will have no effect on a luminaire Le, but will reduce its Ae.

Ae should be a simple, practical measure of the effectiveness of a luminaire in delivering light for a given application. Many applications require general illumination of an entire space without regard for the direction or the distribution of the emitted flux. For these applications luminaire Le can be a useful measure of luminaire effectiveness because this metric is based upon the total lumens produced by the luminaire without regard to direction.

6 CONCLUSIONS

SSL sources have the potential to offer substantial energy savings in general lighting. To accommodate this situation a multitude of new standards, norms and test procedures is needed. There are also many questions and concerns exist in the measurement of LED clusters and arrays. This paper offer specific guidelines for SSL standards in domestic and industrial applications. It is also suggested that the efficacy of Solid-State lighting applications is based upon, the LED lamp and the luminaire (as a system) rather than, solely on LED lamp efficacy. The ability of the luminaire to deliver light in a particular direction and within a particular distribution is very important to characterize the efficiency lighting application.

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AN EVALUATION ALGORITHM ON THE RIGHT OF VIEW USING GRAPHIC PROGRAMS

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ABSTRACT

The right of view is one of the most important factors in providing residents with psychological comfort and stability in residential environment. At present, apartment housings account for more than 50% of housing in Korea. With the construction of high-rise apartments escalating, urban residential areas have become packed with high-rise buildings. As a result, disputes over the infringement of the right of view have been on the increase. According to a court judgement, the view ratio is zero when one's view (with no eye movement) is completely blocked by other buildings. According to the court, when it is more than 40%, the view ratio falls within the range of tolerance. The view range can be analyzed in a disputed area by comparing the view range of the area before the building in question is constructed with that after it is constructed. Therefore, the court uses the view ratios as reference data, by calculating them based on computer simulations, measuring the degree of infringement on the right of view, and analyzing the situation by considering all of these. However, computer simulations of the view range can differ, depending upon the accuracy of the input data - including the types and height of buildings, the distance between buildings, and the altitude - and the characteristics of simulation programs. In this paper, Autodesk VIZ Program and a view program that developed by the authors were used for simulation. The validation was verified to compare the outcome of the simulation with that of an on-spot survey at the apartment housings.

Keyword: View right, Visual privacy, View out, Apartment Housing

1 INTRODUCTION

View is one of the architectural environmental elements affecting human living. As living standards are improving, concern about the quality of life is increasing. Accordingly, disputes over the right to enjoy sunshine and the right of view are increasing. Especially in urban centers, as buildings become increasingly higher, there are many cases of infringing on the right of view that was secured before they were built. In general, if the right of view is infringed upon, one feel psychologically pressured and confined. If the right of view is infringed upon by neighboring buildings, the seriousness rests with continuous infringements instead of one-time infringement, as long as there are buildings being constructed.

If scenery worth viewing exists already and the value of the present building depends considerably on the scenery, infringement on the right of view by construction of a new building could affect the property value of the original building.

There are no established views on the method of measuring the extent of the infringement upon the right of view, and there are actually many difficulties and constraints ensuing from measuring it at the site where dispute has occurred. Therefore, computer simulation is frequently utilized to analyze the extent of the infringement upon the right of view through evaluation of the right of view. With computer simulation, it is possible to measure the view infringement regardless of the construction schedule of the building and view evaluation is possible by assuming the views before and after construction. Consequently, serviceability is high. However, the method and standard for 3D simulation that enables access in various methods are not established and the evaluation standards for evaluating the right of view from the apartment that has the right of view infringed upon are not established either.

This paper aims to propose an evaluation algorithm using 3D simulation program. For this, evaluation of the right of view was made by using the case of J Apartment Housing and validation was verified by comparing the view conditions of actual apartment housing.

1.2 Research Design and Methodology

① Survey and measurement were conducted on the actual condition of the buildings around the J Apartment Housing located in Yongin City, Gyeonggi-do that was selected as an evaluation object, and visits were made to the management office, field office and design office to collect and analyze data including design documents to utilize them as input data. Also, explanation was given about the Autodesk VIZ as a simulation program and a view program developed by the authors.

② 3D modeling for view simulation of S Apartment Housing located southeast of J Apartment was conducted using the results of field trips to the site and analysis of drawings. A simulation method was presented.

③Evaluated the view conditions before and after the construction of S Apartment Housong.

④Compared the view conditions of the actual apartment and the computer simulation based on the same location to verify validation of the findings

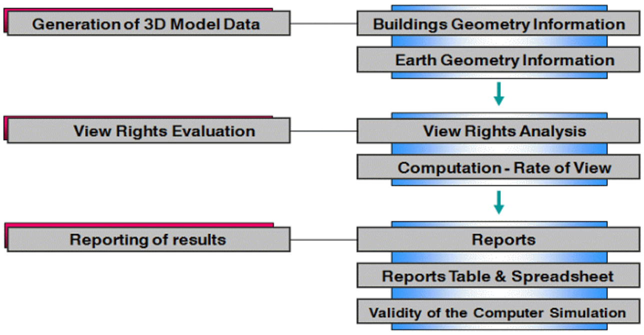


Figure 1 View analysis process

Figure 2 Apartment house layout

2 SUMMARY OF THE APARTMENT HOUSING

2.1 Selection of the Apartment Housing

Selection was made of J Apartment Housing of Yongin City, Gyeonggi-do, the building expected to have its view infringed on. Building 105 of J Apartment House was built with 14 floors, and Building 115 of S Apartment Housing (19 stories high) was built southeast of the J Apartment Housing.

2.1.1. Selection J Apartment Housing

J Apartment Housing consists of 6 buildings and 478 house units with 9 to 18 floors. The story height of each floor is 2.6M for the 1^{st} to 15^{th} floor and 2.8M for the 16^{th} or higher floors due to installation of sprinklers. 6 buildings of the J Apartment site, it was expected that building 105 would have its view infringed upon. That building consists of 14 floors and 6 rows and has an L layout. Of the 96 house units of Building 105 of J Apartment Housing, 14 house units on row 5 and 14 households on row 6 are house units that are expected to have the view infringed upon due to new construction of buildings 114 and 115 of S Apartment Housing.

Building 105 of J Apartment Housing is located west of building 115 of S Apartment House with parking lots for each located between the buildings.

2.1.2. S Apartment Housing

Buildings 114 and 115 of S Apartment Housing located southwest of J Apartment Housing were built anew with 19 floors aboveground and are expected to infringe upon the sunshine and view of building 105 of J Apartment Housing. The shape of the building is as shown in Photo 2.

2.2. View Standards

2.2.1. Legal Aspect of the Infringement upon View

Supreme Court Judgment 2003Da6302 passed on Sept. 13, 2004 set forth the requirements that land or building should have for a view benefit by ruling, “If scenery or view that has been enjoyed by the owner of any land or building is objectively acknowledged to have a value as a living benefit, it can be an object of legal protection. Such a view benefit should not be an object of legal protection, unless it is acknowledged that a specific place has in principle a special value in viewing outside, and the view benefit that the owner or occupant of the building is enjoying from the building has such an importance as to be acknowledged as a socially accepted idea as in the case that the building was constructed in the place with an important purpose of enjoying such a view benefit."

Photo 1 Building 105 of J Apartment House

Photo 2 Buildings 115 and 114 of S Apartment House

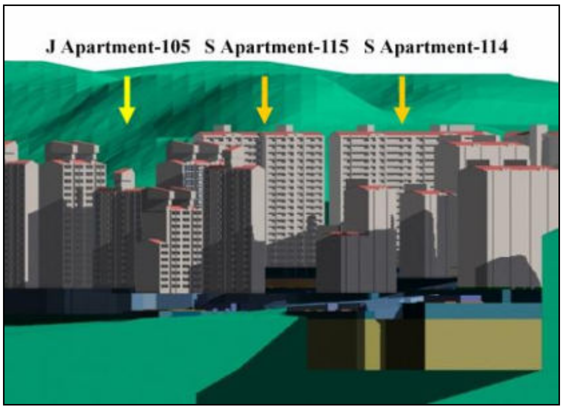


Figure 3 West Elevation

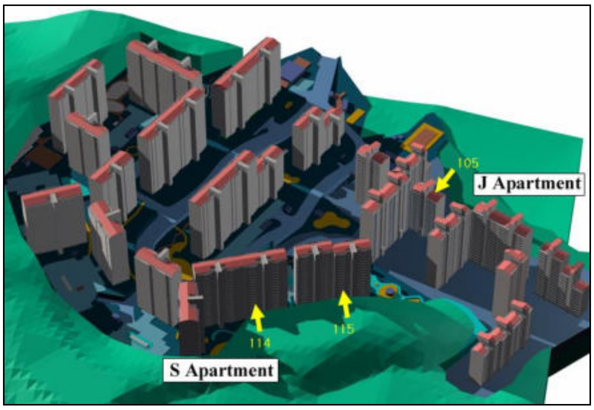
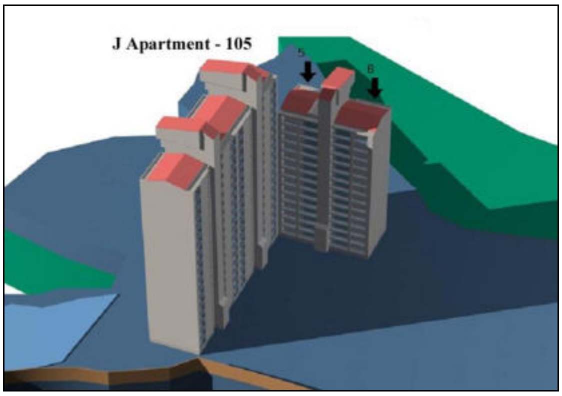
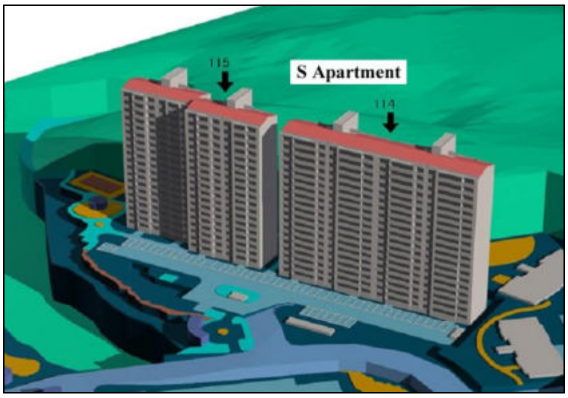


Figure 4 Bird's Eye View



(a) J Apartment House - Existing Building



(b) S Apartment House – New Building

Figure 5 Bird's Eye View

2.2.2. How to Measure the Infringement on View

There are two methods of measuring the infringement on view as follows:

① The view ratio is regarded as 0% if the field of view is completely blocked by obstacles (with no eye movement) and as 100% if it can be seen completely.

② With number 0 for no buildings to due south and 10 for complete infringement by buildings, it is possible to express the extent numerically by classifying 0~2 as normal and 3~5 as bad, etc.

2.2.3. Tolerance limit to view infringement

① Seoul High Court Judgment 99Na5267, 52574 (combined) passed on July 7, 2000 ruled that the view ratio is 0% if the field of view is completely blocked by other buildings with the eye not moving, and if it is 40% or higher it is not unlawful as it is within the tolerance limit.

② Changwon District Court Jinju Branch Judgment 98GaHap980 passed on November 26, 1999 ruled that, by saying that a view is a condition in which you can see scenery by avoiding the opposing building, unlawful infringement is the case of the household where the view from at least one place or more of any of the center of the living room and from the sitting room in front of the living room of the infringed building is blocked 100%.

③ In Seoul High Court Judgment 94Na11906 passed on March 29, 1966 and Seoul District Court Euijeongbu Branch Judgment 2000GaHap2792 passed on May 9, 2001, a perforation rate is measured as a method of measuring view infringement. With a perforation rate of 0 for no buildings and 10 for high-rise buildings in due south, it was ruled that the tolerance limit was exceeded if a certain standard of numerical value was exceeded.

3 VIEW EVALUATION METHOD

3.1 Selection of View Simulation Programs

As simulation programs for view evaluation, AutoCAD and Autodesk VIZ, which are generally used in architectural design, were selected, and a self-developed view program was selected to calculate the view area of the building to be evaluated.

The program was to calculate the number of pixels of a specific color of image, and display it by ratio. Since it is possible to control the color of the perforated portion when an image is generated by using the render function of Autodesk VIZ, we can obtain the ratio for a specific color. The program was made by using the Bitmap function of Visual Basic 6.0, and the area ratio was displayed by searching the white color on the monitor in dot unit based on a resolution of 1024×768.

3.2 Method of Evaluating the View of the Target Apartment House

3.2.1 Input of Building Data

After confirming whether the layout, floor plan, elevation, sectional view, survey plan, etc. of the apartment house agree with the actual site, an accurate 3D model was made using AutoCAD. For the orientation and location of the apartment house site, I referred to the digital map of the same number of lot manufactured by the National Geographic Information Institute of the Ministry of Construction and Transportation. Layer setting for simulation on Autodesk VIZ was divided by building. Since the view from the J Apartment House should be accurately expressed, precise modeling was made of the structure of the roof and penthouse of S Apartment Housing.

3.2.2. Setting View Analysis

The model made on AutoCAD was linked with Autodesk VIZ by using the file link manager function. The scene (as observed when a person 170cm tall looked out the window in the perpendicular direction while sitting in the center of the living room of the household to be evaluated) was created by computer simulation to analyze the view ratio of each household. The height of the analysis point was set as the value obtained by adding the eye height (0.9 m) with the observer sitting on the living room floor of each room (the living room floor according to the drawing obtained).

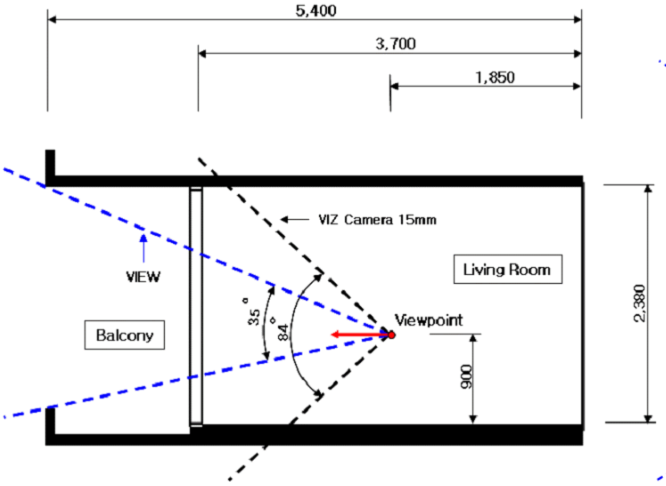


Figure 6 Section

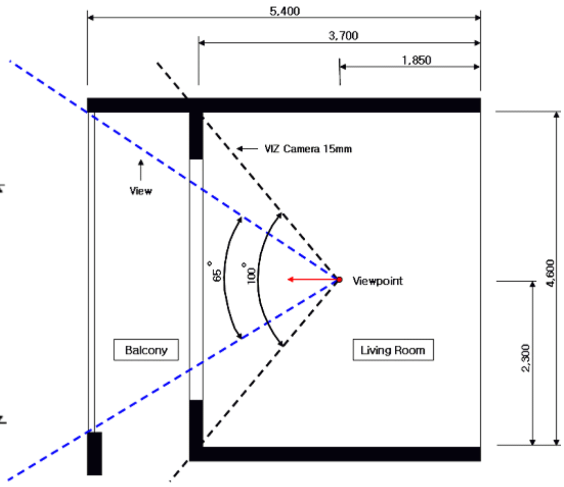


Figure 7 Plan

3.2.3 View Analysis Model

An accurate 3D model is required for measuring the view. For this, a site model was made by using the digital map marked with contour lines of the National Geographic Information Institute to find out the view condition from each houseunit that has its view infringed upon before S Apartment Housing was constructed anew.

The digital map of the National Geographic Information Institute not only has the elevation of contour line marked but also is made three-dimensionally, so it is possible to make a three-dimensional site model. By using the drape function of Autodesk Architectural Desktop program, precise modeling was made of the topography on the 3D digital map.

4 EVALUATION OF RIGHT OF VIEW

4.1 Summary of View Evaluation

The view ratio was calculated as a percentage (%) of the area not obstructed by the existing and new buildings to the area viewed out of the window. At this time, the area viewed out of the window of the living room was calculated as the opening area. The mountains that existed before new construction of the infringing building were included with other view elements such as the sky. The results of analysis were organized by household opening area, view ratio (%) before new construction, view ratio (%) after new construction and infringement on view ratio (decreased view ratio) due to new construction.

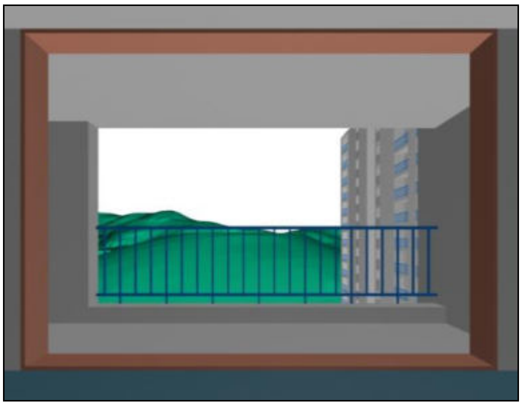


Figure 8 View before new construction
S Apartment House

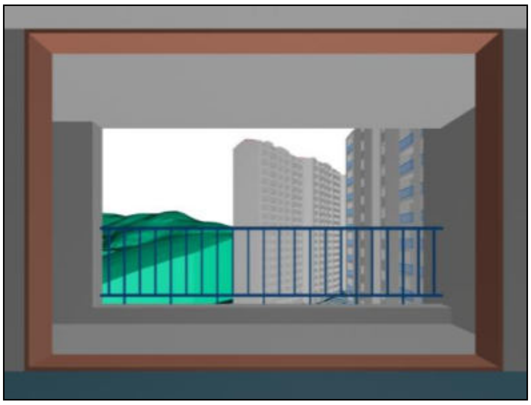
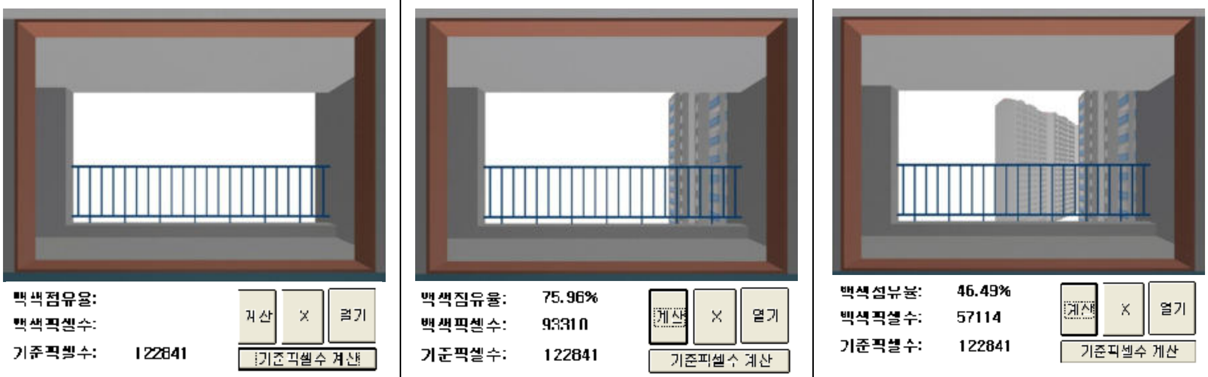


Figure 9 View after new construction
S Apartment House

4.2 Calculation of View Ratios Using View Program

To calculate the view ratio, the reference number of view pixels should be calculated. In the present paper, the total number of white color pixels of the outside seen through the opening on the side of balcony window from the center of the living room was calculated and then this was set as 100%.

Building 105 of J Apartment House is an L-shaped apartment house, so part of the opening view on the side of balcony of the living room is already blocked by the building itself. So this was re-calculated based on the reference number of pixels. The calculated white color occupation ratio becomes the view ratio of the apartment house itself.



(a) Reference View of J Apartment House	(b) View Ratio by the Building Itself of J Apartment House	(c) View Ratio After New Construction S Apartment House

Figure 10 Calculation of View Ratios

The white color occupation ratio is calculated by calculating the number of white color pixels based on the reference number of pixels including the newly constructed apartment house. The calculated white color occupation ratio becomes the view ratio with the newly constructed apartment house included.

To generate view images, free camera was used on Autodesk VIZ and after positioning it accurately at the center of the living room, variables were input as shown in <Table 1>.

Table 1 Autodesk VIZ - Camera setting

Items	Input Parameters			
Lens	15mm			
FOV	↔	100.389 deg	↕	83.974 deg
Type	Free Camera			
Installation location	Center of living room			
Installation height	900mm			

4.2.1 View Ratios of Row 5 of J Apartment Housing

The average view ratio of 14 houseunits on row 5 of building 105 of J Apartment House before new construction of S Apartment Housing was 68.48% and the average view ratio after new construction was 42.07%, so the decrease in view ratio due to new construction of S Apartment House was 26.41%. In the case of household No. 1005, the view ratio before new construction of S Apartment House showed 69.36%, but it was 38.71% after new construction, showing a decrease in view ratio of 30.65%, which was the largest decrease in view ratio of 14 floors. Because the new S Apartment House was built on the mid-slope of the mountain on the southeast of J Apartment House, the view ratios decreased more in the mid- and high-rise portions than the low-rise portion.

Table 2 Row 5 of J Apartment House View Ratios Before and After New Construction of S Apartment Housing

Row	Number	Before New Construction of S Apartment Housing (%)	After New Construction of S Apartment Housing (%)	Decreased Due to New Construction of S Apartment Housing (%)
5	105	63.99	43.52	20.47
	205	59.35	38.18	21.17
	305	64.39	42.18	22.21
	405	69.39	45.87	23.52
	505	69.34	44.40	24.94
	605	69.36	42.93	26.43
	705	69.41	41.51	27.90
	805	69.31	40.11	29.20
	905	69.36	39.18	30.18
	1005	69.36	38.71	30.65
	1105	69.37	38.95	30.42
	1205	69.37	40.20	29.17
	1305	69.64	42.00	27.64
	1405	77.13	51.23	25.90

Table 3 Row 6 of J Apartment House View Ratios Before and After New Construction of S Apartment Housing

Row	Number	Before New Construction of S Apartment Housing (%)	After New Construction of S Apartment Housing (%)	Decreased Due to New Construction of S Apartment Housing (%)
6	106	88.48	63.87	24.61
	206	86.86	61.57	25.29
	306	85.57	59.06	26.51
	406	85.07	57.08	27.99
	506	84.97	55.42	29.55
	606	84.96	53.91	31.05
	706	84.99	52.54	32.45
	806	85.03	51.34	33.69
	906	84.97	50.54	34.43
	1006	84.92	49.99	34.93
	1106	85.01	50.35	34.66
	1206	85.01	51.74	33.27
	1306	85.52	53.96	31.56
	1406	95.45	65.70	29.75

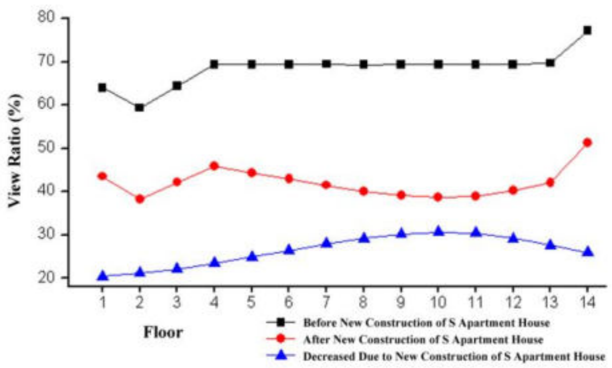


Figure 11 Comparison of view ratios on row 5

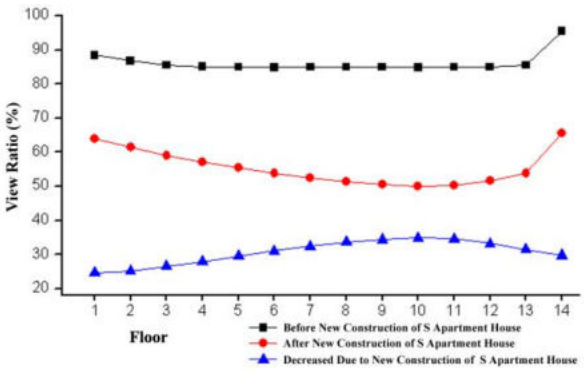


Figure 12 Comparison of view ratios on row 6

4.2.2 View Ratios of Row 6 of J Apartment House

The average view ratio of 14 households on row 6 of J Apartment House before new construction of S Apartment House is 88.20% and the average view ratio after new construction is 55.51%, with a decrease of 30.70% due to new construction of S Apartment House. For household No. 1006, the view ratio before new construction of S Apartment House showed 84.92%, but it decreased 34.93% to 49.99% after new construction, showing the greatest decrease in view ratio of 14 floors.

5 VALIDATION OF COMPUTER SIMULATION

To verify the validation of simulation results, the actual view photograph of the apartment house and the view photograph of the simulated image were compared. The program cannot be said to be usable for view evaluation unless the image of the view as seen by using the camera of Autodesk VIZ program is identical to the photograph actually taken on the same floor and same location.

Photo 3 is a picture taken at No. 606 of building 105 of J Apartment House to verify validity of the view evaluation. The structure of building 105 itself is seen on the left side and part of buildings 115 and 114 of S Apartment House are seen on the front. You can see the open cut section and the ridge of the hill on the left.

The image in Fig. 17 is a simulation of the view ratio as seen from the same place and at the same time of the picture-taking, to verify validity. Comparison between the view of the actual photograph and the view of the simulation image showed that the locations of S Apartment House and the ridge of the hill match each other.

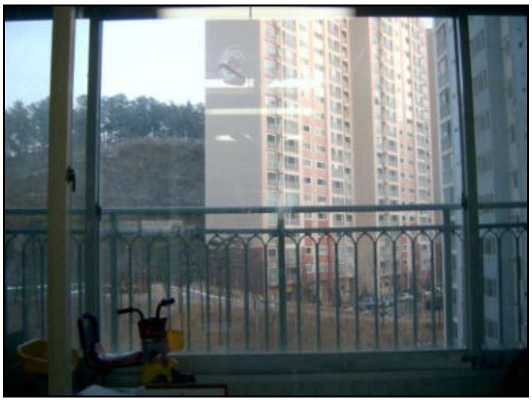


Photo 3 View picture of No. 606 of J Apartment House

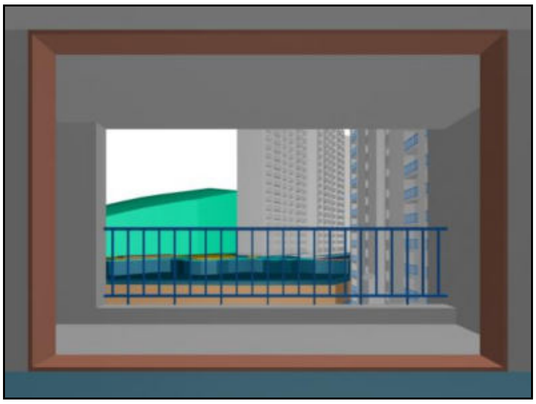


Figure 13 View image of No. 606 of J Apartment House

6 CONCLUSION

An evaluation algorithm of the view night using graphic programs was presented and the followings are the results.

1) Design drawings such the layout, floor plan, elevation, sectional view of the building and the survey plan of the site are needed to make a simulation model for view evaluation, and the solid model function of AutoCAD was shown to be able to make a 3D model accurately for simulation.

2) The camera and render functions of Autodesk VIZ were shown to have high accuracy, and the 3D model for simulation proved capable of increasing the degree of understanding of view infringement by apartment household by visualizing the views before and after new construction in realistic images for actual view evaluation.

3) A program by which view ratios can be abstracted and calculated is required for accurate calculation of the view ratios of simulation images. Therefore, a view program was developed to calculate the view ratios and it was possible to improve calculation errors that may be generated from a manual calculation method and shorten the time required for calculation.

4) The results of analyzing the right of view showed that the average view ratio of 28 households on row 6 of building 105 of J Apartment House was 77.34% and the average view ratio after new construction was 48.79%. The view infringement ratios due to new construction of S Apartment House showed from maximum 30.65% to minimum 20.47% for row 5, and the view infringement ratios for row 6 were analyzed to be from maximum 34.93% to minimum 24.61% with the average view infringement ratio of 28.56%.

5) The simulated view images and actual photographs were compared based on the same floor and same location, and the result showed the view shape and location match each other.

6) Sunshine evaluation using 3D modeling verified accuracy in the view evaluation case of J Apartment House, and accurate view evaluation was found to be possible regardless of various shapes of building.

ACKNOWLEDGEMENTS

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ROLUL COMITETELOR NAȚIONALE DE ILUMINAT ÎN UNIUNEA EUROPEANĂ

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Organizatiilor civile in general, dar mai ales asociatiilor de specialitateîn particular, le revine un rol important in lumea globalizata. Noile state care au aderat la UE se vor confrunta cu noi probleme fara precedentt la nivel national. Asociatiile de specialitate au datoria de a participa la activitati cum ar fi: introducerea noilor standarde europene omologate, in locul standardelor nationale, exercitarea unui lobby in faza de concept ale unor prescriptii, participare la programe lansate de Uniunea Europeana precum si organizare de programe la nivel national, realizare de noi contacte cu alte asociatii din UE, schimb de experienta, conlucrare cu acestia in sustinerea programelor comune la nivel de Uniune. Deci putem spune ca modul de gandire „la nivel national” va trebui in curand inlocuit cu modul de abordare „la nivel de UE”.....

Introducere

Comitetele nationale de iluminat din cadrul CIE au desfasurat activitati de colaborare in elaborarea unor prescrieri si pana-n prezent putem spune ca prin intermediul CIE a existat posibilitatea de afirmare a intereselor nationale la nivel european. Este bine stiut si faptul ca in cadrul unor conferinte de specialitate s-au dezbatut idei care au ajutat foarte mult la dezvoltarea activitatilor de specialitate ale unor tari. Relatiile bi sau multilaterale intre organizatiile nationale de iluminat au inchegat relatii profunde si ajuta in continuare la stabilirea unor noi relatii intre oamenii de specialitate din diferite tari ale uniunii.

Totusi ce s-a schimbat in ultimii ani?

Locul nostru in cadrul Uniunii Europene

Multi dinre noi admitem ca UE s-a extins intr-un mod semnificativ. Integrarea noilor state creeaza noi probleme in cadrul UE ale caror rezolvare va dura mai mult sau mai putin, iar asociatiile de specialitate vor avea posibilitatea de a se implica in rezolvarea lor. Nu e intamplator ca in zilele noastre in Bruxelles exista circa 3000 de organizatii de lobby. Toate domeniile de specialitate, toate profesiile isi exercita influenta in cadrul elaborarii noilor proiecte de legi si planuri de actiuni sau hotarari pentru apararea intereselor care ar putea afecta pe termen scurt sau lung existenta profesionala sau materiala. In cadrul acestor organizatii se poate aminti atat Asociatia Producatorilor de Lampi (ELC) cat si Asociatia Producatorilor de Aparate de Iluminat (CELMA). De exemplu CELMA a fost organizatia care a avut un aport important in luarea deciziei cu privire la apartia marcajului CE pe produsele fabricate in Europa. Sigur, asta nu inseamna ca astfel au reusit sa impiedice aparitia pe piata a unor produse de calitate indoielnica. Actualmente ambele organizatii exercita lobby in cadrul programelor de eficientizare energetica pentru ca tehnica iluminatului sa ocupe un loc important in acest program. Din acest motiv, Comitetelor Nationale de Iluminat li se deschid noi perspective de a lucra pe proiecte de nivel European.

Locul nostru la nivel national

In conditiile economice si politice actuale din Ungaria, noi a trebuit sa ne redefinim rolul, misiunea si obiectivele. Cred ca si Dvs.ati procedat la fel, deoarece sistemul s-a schimbat si aici, iar eu nu sunt singurul care constata ca tara Dvs. se dezvolta intr-un ritm fantastic. Fara doar si poate, in aceasta perioada de dezvoltare va revine o sarcina extraordinar de grea de a promova ideea iluminatului eficient si de calitate. Problema mare e ca in aceasta perioada actioneaza pe piata firme care nu au nimic in comun cu acest tip de iluminat iar procesul de eliminare a lor de pe piata este greu din punct de vedere practic, daca nu imposibil.

In cele ce urmeaza as vrea sa impartasesc cu Dvs. unele cazuri din activitatea noastra care ar putea fi de folos in rezolvarea problemelor Dvs.

Dupa cum bine stim standardele n-au caracter de obligativitate, ci mai degraba sunt cu titlu de recomandare. Norma europeana EN 12464 referitoare la iluminatul spatiilor de lucru a devenit obligatorie in urma repetatelor scrisori adresate Ministerului Muncii prin care ceream modificarea unei hotarari de guvern existente la acea data.Ca urmare guvernul a solicitat organizatiei VTT elaborarea unui proiect de lege. Astfel norma EN12464 a devenit obligatorie odata cu publicarea in monitorul oficial.

Directivele europene WEEE specifica obligativitatea colectarii lampilor si aparatelor de iluminat defecte-uzate de pe piata. VTT s-a alaturat Ministerului Mediului in activitatea de elaborare si punere in practica a directivei europene. Ne-am straduit la obitnerea unei cote cat mai mici de recuperare. Datorita lobbyului HG 464 vine in sprijinul activitatii firmelor de iluminat locale. Stim ca activitatea de colectare costa bani, de aceea asociatia VTT a convocat toate firmele indiferent daca sunt membre sau nu ale asociatiei VTT cu scopul impunerii unei taxe unice de colectare astfel evitandu-se competitia pe piata iluminatului. S-a constituit o comisie de lucru pentru organizarea licitatiei de alegere a celei mai bune oferte de colectare, dupa care castigatorul a semnat contractele de colectare cu fiecare firma in parte.

In urma acestei actiuni, au avut de castigat atat jucatorii de pe piata iluminatului cat si VTT pe plan moral reusind sa atraga noi membri.

Deasemnea tot ca urmare a activitatii de lobby am reusit eliminarea taxei pe produs existenta si aplicata in Ungaria pentru o serie de produse de larg consum.

Asociatia noastra este implicata in mod activ in elaborarea strategiei nationale de eficienta energetica ce trebuie finalizata/predata la Bruxelles pana pe data de 30 iunie a.c. Dorim ca tehnica iluminatului sa fie un capitol distinct in aceasta strategie, de aceea am pus la dispozitia Ministerului Economiei documente tehnice cat si calcule de eficienta energetica care sa vina in sprijinul strategiei de economie energetica a Ungariei.

Materialele prezentate au fost elaborate pe baza recomandarilor ELC si CELMA pentru a se inscrie in tendintele europene. Noi, VTT, avem un dialog permanent cu ELC si CELMA, dar si cu reprezentantii nostri in Comisiile Europene de specialitate cu scopul de a-i informa despre posibilitatile locale si europene. Scopul nostru este de a introduce iluminatul in strategia energetica a Uniunii Europene.

Bineînteles cele de mai sus nu descriu intreaga activitate a VTT-ului. Pe langa aceste ativitati promovam dezvoltarea culturii iluminatului prin publicarea de studii, anuare si alte actiuni

Concluzii

Globalizarea nu mai este o noutate in zilele noastre de aceea datoria noastra este de a ne integra promovand cultura noastra si in domeniul iluminatului.

In acelasi timp, pe plan national urmarim mentinerea calitatii prin respectarea standardelor ce ni le-am impus in concordanta cu cele euorpene.

Doresc mult succes colegilor romani din CNRI.

EXPERIMENTAL INVESTIGATION OF THE HARMONIC POLLUTION PROVIDED BY SOME ELECTRIC DISCHARGE LAMPS IN DISTRIBUTION NETWORKS

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ABSTRACT

Most applications of artificial lighting are based nowadays on the utilization of sources such as electric discharge lamps, which are capable of providing lighting systems with superior technical lighting features when much more reduced energy consumption are used as compared to incandescent tungsten-filament lamps.

Electric discharge lamps are high-performance sources largely used in lighting systems to fulfill various specific lighting requirements. However, they provide harmonic pollution at the interface with the electrical supply network.

The paper presents the results of the experimental researches developed in order to study the distorting state main indicators (harmonic spectrum of the main voltage, harmonic spectrum of the absorbed current, total harmonic distortions factor) of some electric discharge lamps (fluorescent lamps with conventional electromagnetic and electronic ballasts, high intensity discharge mercury lamps, blended light lamps) comparative to incandescent tungsten-filament lamps.

1 INTRODUCTION

Most applications of artificial lighting are based nowadays on the utilization of sources such as electric discharge lamps, which are capable of realising lighting systems with superior technical lighting features when much more reduced energy consumption are used as compared to incandescent tungsten-filament lamps.

Another positive aspect, with a favourable impact on diminishing the operation and maintenance costs of lighting systems, is the rated operating life time of discharge lamps which is about 4-15 times larger than that of incandescent lamps. [1, 2].

In contrast with the above-mentioned benefits, all electric discharges lamps are characterized by a distortion status, mainly due to the specific non-linearity of the electric discharge processes in gases as well as the non-linearity of the circuitry components required for striking and stabilizing the discharge in the lamp.

2 CHARACTERIZATION OF ELECTRIC DISCHARGE LAMPS

The discharge lamps present a non-linear V-A curve with a descending slope, a fact that confers them the features of negative dynamic resistance (r_{dl}), as expressed in the relationship (1), where U_L represents the lamp voltage and I_L, the lamp current respectively:

$$r_{dl} = \frac{dU_L}{dI_L} < 0 \tag{1}$$

When the lamp is disconnected (not supplied), it behaves like an open circuit and a higher voltage is required to strike the non-ionized cold gas column.

When the lamp is in operation, the ionized gas column (plasma) has a reduced resistance (tens-hundreds of Ohm) with a negative dynamic character: the higher the lamp current is, the more slightly the lamp voltage decreases.

Hence, the electric discharge lamps have to be supplied from alternative current sources with high output impedance, in order to limit the current and to avoid the lamp destruction by an excessive current. In view of ensuring a stable operation in stationary state, it is necessary to meet the condition that the sum of the positive source impedance and the negative dynamic resistance of the lamp should be positive.

The common a.c. supply equalizes electrodes erosion over the life-span of the discharge lamp, but, at low industrial frequency, it generates the flickering effect due to discharge cutting-off and restriking in each halftime when supply voltage passes through zero point. With high-frequency sources (tens of kHz) a continuous operation is reached, that is a constant lighting of good quality and other important improvements of discharge lamps performances. [3].

Both in the case of circuits with conventional inductive ballast designed for discharge lamps a.c. supply at industrial frequency (50 Hz) and in that of using electronic ballasts for high-frequency supply, the low power factor and the high harmonic distortions are the main effects with a negative impact upon the electric power quality at the interface with the supply network.

3 DISTORTING STATE CHARACTERIZATION

In order to evaluate quantitatively the distorting state, some specific characteristic quantities and indices have been established based on determining harmonic spectra of electric periodical non-sinusoidal parameters in permanent state by means of the Fourier series. [4, 5, 6].

For the single-phase circuits case in distorted state, the electric powers can be defined in more suitable ways, so that [7]:

- the apparent power has two components:

$$S^2 = S_1^2 + D^2 = (U \cdot I)^2 \tag{2}$$

where:

$$S_1^2 = P_1^2 + Q_1^2 = (U_1 \cdot I_1 \cdot \cos\varphi_1)^2 + (U_1 \cdot I_1 \cdot \sin\varphi_1)^2 \tag{3}$$

is the fundamental apparent power, with active part (P_1) and reactive part (Q_1) expressed in terms of effective values for fundamental voltage (U_1) and current (I_1),
whereas:

$$D^2 = D_I^2 + D_U^2 + D_{UI}^2 = (U_1 \cdot I_d)^2 + (U_d \cdot I_1)^2 + (U_d \cdot I_d)^2 \tag{4}$$

is the total distorsion power with the components: distorsion power (D_1) of ID type, distortion power (D_U) of UD type and apparent harmonic power (D_{UI}), expressed in terms of effective fundamental values (U_1, I_1), and deforming residues (U_d, I_d) for voltage and current.

Only the active power (P_1) and the reactive power (Q_1) corresponding to fundamentals have a physical significance and a well-defined flow sense. The other components represent but formal products, their role being that of useful indices for investigating the operation of electrical network in a distorting state.

The following factors are defined as follows:

- the distorting power factor :

$$k_{pd} = \frac{D}{S_1} \cong \sqrt{k_{dI}^2 + k_{dU}^2} \tag{5}$$

expressed with a good approximation in terms of distorting factors for current (k_{dI}) and voltage (k_{dU}) under the most frequently encountered circumstances in electrical low-voltage networks (k_{dU}<0,05, k_{dI}>0,4 respectively, typical values.)

- the harmonic distorting power factor:

$$k_{pdh} = \frac{D_{UI}}{S_1} = k_{dI} \cdot k_{dU} \tag{6}$$

with values $k_{pdh} \leq 0{,}02$ under the above mentioned conditions.

The most efficient index of power flow in a system is, nevertheless, the total power factor:

$$k = \frac{P}{S} = \frac{\cos\varphi_1}{\sqrt{1 + k_{dI}^2}} \tag{7}$$

expressed in terms of the fundamental power factor (*cos*φ_1) and the current distortion factor (k_{dI}) – indices giving a significant importance in a ID-type distorting state (sin – wave voltage).

To understand properly and clearly the contribution of each harmonic to the electric power flow, a relevant image regarding the behaviour of a non-linear receiver can be obtained only by a complete analysis in amplitude and phase of voltage and current harmonics.

The suitable international institutions (CEI, CENELEC), have worked out proper standards with the aim of limiting harmonic pollution of electric networks.

According to the stipulations of norm NF EN 61000-3-2 (elaborated in 1998 in accordance with the technical requirements of standard EN 60555-2), the admissible limits for harmonic currents emission corresponding to the products group “lighting equipments” incorporated in class “C” are presented in table 1 [5].

Table 1

Harmonics order	Odd harmonics						Even harmonics			
	3	5	7	9	11	>13	2	4	6	>8
$\frac{I_{n\max}}{I_1}\cdot 100$ [%]	30*k	10	7	5	3	3	2	-	-	-

4 EXPERIMENTAL RESULTS

The experimental study on the distorting state provided by electric discharge lamps consisted in determining the main characteristic indices (harmonics spectra of network voltage, harmonics spectra of absorbed current, distorting factors for voltage and currents, power factors) for the following representative cases:

1. Tubular fluorescent lamp LFA 20/2 (ROMLUX – Târgovişte) with inductive ballast BIF 20 (ROMLUX) and preheat starter SLB 20 (ROMLUX) with the rated features of: U_N=220Vac/50Hz; P_N=20 W, I_N=0,37 A, $cos\varphi_N$=0,38.
2. Compact fluorescent lamp with incorporated electronic ballast MINI-LYNX INSTANT (SYLVANIA – UK), with the rated features of: U_N=220-240 Vac / 50/60 Hz; P_N=20 W, I_N=0,158 A.
3. High-pressure mercury lamp HPL – N 125 W (PHILIPS –Belgium) with inductive ballast BHL – 125 L (PHILIPS) with the rated feature of: U_N=230 Vac/50 Hz; P_N=125 W, I_N=1,15 A, $cos\varphi_N$=0,55.
4. Blended light lamp ML 160 W (PHILIPS – Belgium) with the rated features of: U_N=220 Vac/50 Hz; P_N=160 W.
5. Normal incandescent lamp LIC –200 W (ROMLUX – Târgovişte) with the rated features of: U_N=230 Vac/50 Hz; P_N=200 W, bulb: clear, lamp cap E 27. This case was investigated only for comparison purpose.

The electric – energetic behavior at the interface with the supply network has been characterized in correlation with the main lighting performance parameters: the total luminous flux and the lighting efficacy determined by specific experimental procedures. [8]

All electro-energetic parameters of interest measured simultaneously with the determination of voltage and current harmonics by means of Fast Fourier Transformation (FFT) have been achieved by means of a digital Power Analyzer, type D 4010S. [9].

The main electro-energetic and lighting parameters measured and calculated for the studied cases (1 to 5) are synthetically presented in table 2.

The harmonics spectrum for the supply voltage is presented in Figure 1, and the harmonics spectra for the absorbed currents are rendered in Figure 2 for case 1, Figure 3 for case 2, in Figure 4 for case 3, in Figure 5 for case 4 and in Figure 6 for case 5.

Table 2

Lamp type	U [Vef]	k_{dU} [-]	I [Aef]	k_{dI} [-]	P [W]	k [-]	□ [lm]	□ [lm/W]
1	220	0.03814	0.3762	0.13712	35.675	0.43091	880.2	24.234
2	220	0.06107	0.1655	0.83467	18.617	0.51123	1190.7	63.956
3	230	0.05518	1.1424	0.10009	140.02	0.53273	4913.4	35.09
4	220	0.03162	0.6937	0.29463	144.51	0.94639	2155.3	14.914
5	234.5	0.04813	0.8555	0.04639	200.6	0.99998	2520	12.562

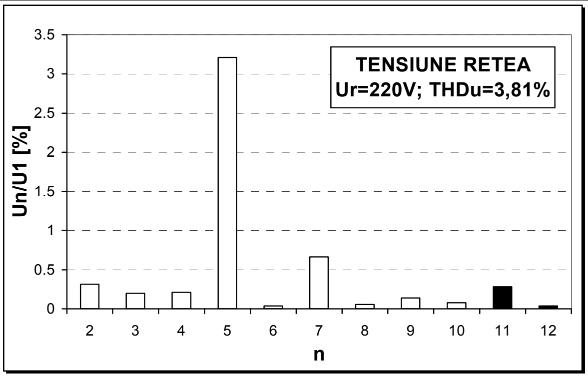

Figure 1 The harmonic spectrum of the supply voltage (U_r=220V, THD_u=3,814%)

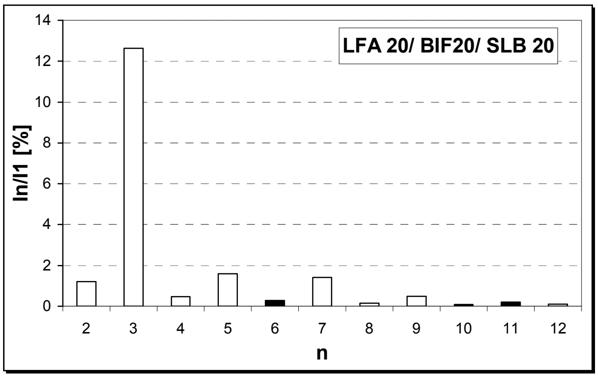

Figure 2 The harmonic spectrum of the current Lamp LFA 20/2 + BIF 20 + SLB20

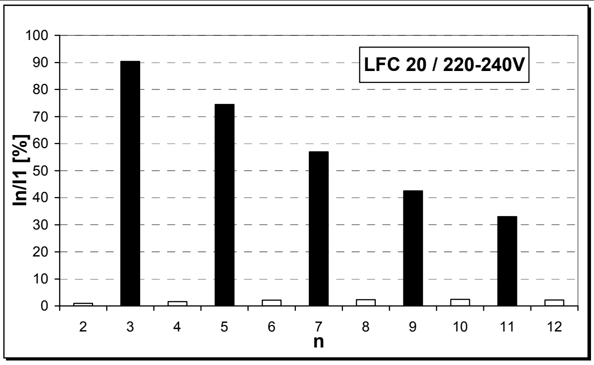

Figure 3 The harmonic spectrum of the current (Lamp LFC 20 W/220-240 V)

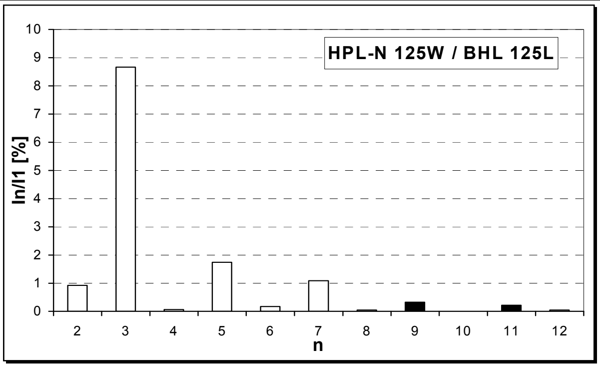

Figure 4 The harmonic spectrum of the current (Lamp HPL-N 125 W + BHL 125L)

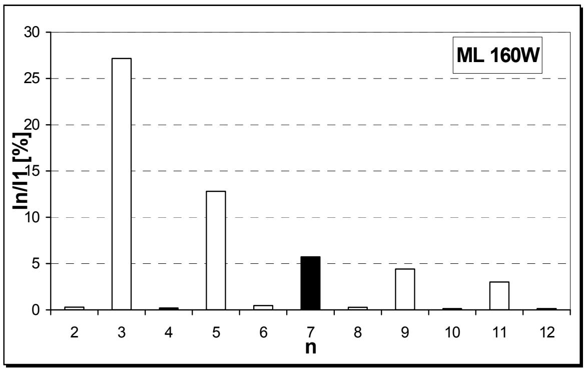

Figure 5 The harmonic spectrum of the current (Lamp MLV 160W)

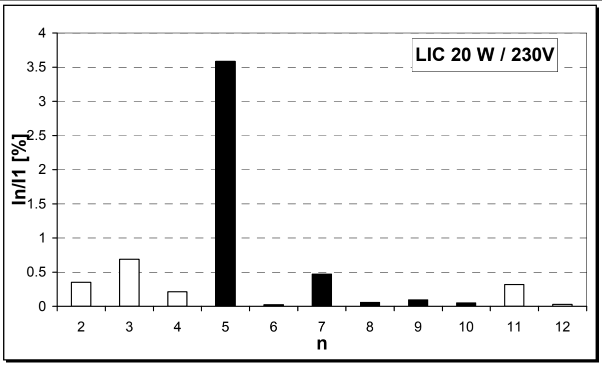

Figure 6 The harmonic spectrum of the current (Lamp LIC 200W/230V)

5 CONCLUSION

The electric discharge lamps (cases 1-4) experimentally studied are not provided with filtering devices (active or passive) at the interface with the electrical supply network, so that the harmonics spectra determined and presented in the paper point out the “natural” character of an ID-type distorting load.

Under the circumstances of a network supply voltage that presents a slight distortion mainly due to the order 5 harmonics experimentally detected in all cases (Figure1 and the corresponding values k_{dU} in Table 2), the following relevant aspects are to be outlined:

- the lamps case 1, case 3, case 4 are characterized by an ID-type distorting state, the current harmonics acceptably meeting the requirements of standard EN 61000-3-2, class C;
- the lamp case 2 displays a strong deforming ID-type character, by far exceeding the legal norm stipulations in use, although, comparatively, they present the best luminous performances;

- the lamp case 5 does not introduce a distorting state (the order 5 harmonics present in the absorbed current are due to a slight distortion in the supply voltage).

Since the harmonic distortions in the absorbed current may bring about problems in the electrical supply network (overcharge of the null conductor, overheating of transformers, errors of and in measuring gauges, interference troubles etc.), it is of utmost importance to take appropriate measures in reducing the distorting state provided by electric discharge lamps.

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ANALYSIS ON SURFACE LUMINANCE OF SHOPPING BUILDING BY OUTDOOR LIGHTING

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ABSTRACT

Seoul Metropolitan Government (SMG) began to restore the Cheonggyecheon(stream) for urban ecological rehabilitation with sustainable urban lighting master plan in 2003 and completed in October,2005. The various lightings are functionally installed to enable diverse transformation of the stream's nightscape. However, most buildings around the stream have been illuminated with its own particular spatial function and also have had the potential inharmony on nightscape. Four shopping complexes in the commercial area adjacent to the stream are chosen, and the surface luminance was measured to discuss.

1 INTRODUCTION

The Cheonggyeocheon area was originally the urban natural stream. Beginning with concrete pavement in 1955, it was built for expressway. It was restored as the original stream for the purpose of urban regeneration in 2005. The outdoor lighting plan for Cheonggyeocheon was implemented in the initial stage of the plan by integrating with the master plan. However, the buildings located around the stream have already had lighting facilities. In particular, the shopping complexes adjacent to the stream have the large area of elevation with outdoor lighting.

Therefore, the purpose of this paper is to measure the surface luminance for the shopping complexes that are located within the commercial area and to analyze the impacts on the lighting environment of Cheonggyeocheon. According to Korea Standards (KS C 7613:99), the preliminary measurement were conducted using the CS-100 photometer, and four measurement points were selected and ProMetric 1400was used for the main measurement. The Radiant Imaging was used to analyze the luminance environment.

Figure 1 Aerial Scene of Cheonggyeocheon

2 OVERVIEW OF SHOPPING COMPLEXES

The shopping complexes located in the commercial district were chosen for the study. The commercial area is the district of total 1.8km from the southern starting point in 2.16km to 3.96 km from the total length of 5.84km for Cheonggyeocheon. The buildings are located with the two lanes road with 6m width between. The building names of Pyunghwa, Shinpyunghwa, Dongpyunghwa and Chungpyunghwa were selected as the shopping complexes. The width of dimension to encounter with Cheonggyeocheon and selected buildings was in the range of approximately 120m up to approximately 600m, with the height of 3-story underground and 6-story on the ground. The scenic lighting of the building uses the Metal Halide Lamp floodlight overall to emphasize the exterior of the building, and neon, LED, cold cathode are used in part for different display effect.

Table 1 Overview of Shopping Complexes

	day	night	characteristic
Pyung hwa			- Structure : R.C - floor : 3 - width size : 600 m - business hour : 21:00~06:00
Sin pyung hwa			- structure : R.C - floor : 4 - width size : 170m - business hour: 22:00~10:00
Dong pyung hwa			- structure : R.C - floor : 4 - width size : 170m - business hour: 24 hours a day
Chung pyung hwa			- structure : R.C - floor : 6 - width size : 120m - business hour: 05:00~19:00

3 MEASUREMENT

For measuring the nighttime surface luminance of shopping complexes, the measurement was determined after the sunset, in consideration of the business hours of the buildings. Four areas of measurement were selected to see the subjects of measurement and surrounding buildings simultaneously. By using the 17mm camera lens of maximum picture angle 104, the surface luminance of the shopping complexes, surface of outdoor advertisement and sky luminance were selected.

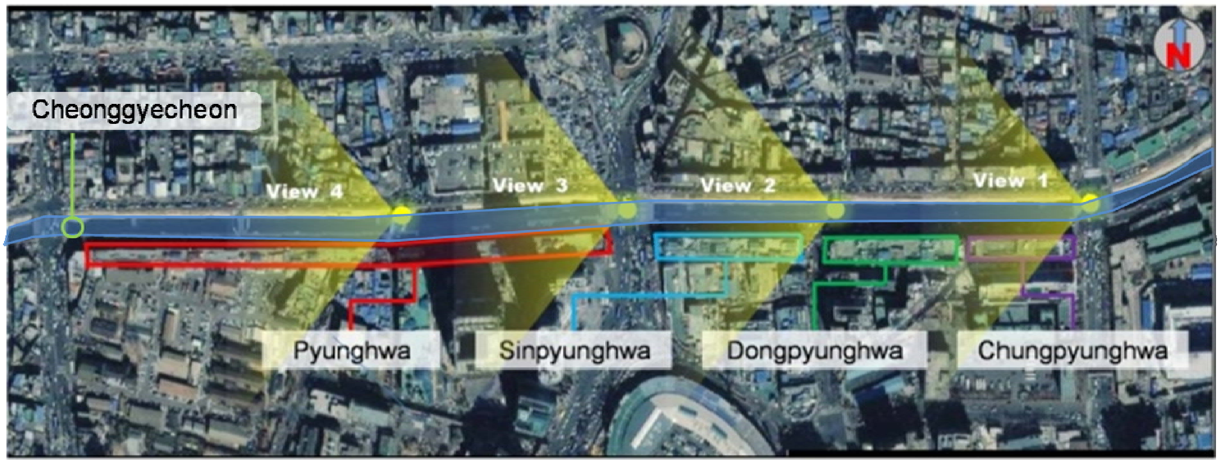
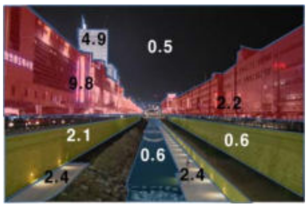
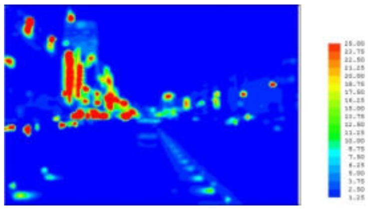
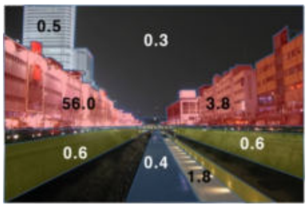
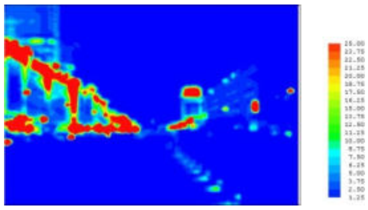
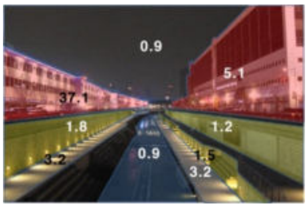
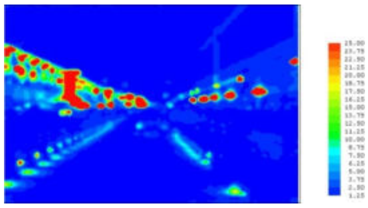
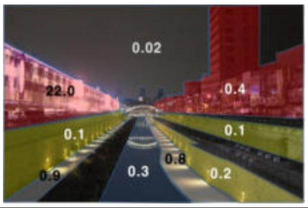
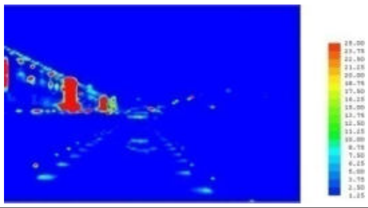


Figure 2 Views of Location and Measurement of Building Subject for Measurement

4 ANALYSIS OF LUMINANCE ENVIRONMENT

Table 2 Luminance Characteristics in the Central View of Cheonggyeocheon

view	scene	luminance	luminance distribution (exceed CIE Recommendation)[3]
1			
2			
3			
4			

1) View 1
On View 1, Chungpyunghwa and Dongpyunghwa buildings are shown. The surface luminance is as followings; 9.8cd/㎡ for the subject buildings, 0.5cd/㎡ for the sky luminance, 2.4cd/㎡ for the hiking path, 0.6-2.1cd/㎡ for the walls of the hiking path, 2.2cd/㎡ for the northern buildings. The luminance ratio between the buildings and sky luminance was 1:20, and with the two elements (the walls of hiking path and northern building), the ratio were both the same as 1:5. In case of northern buildings, luminance ratio against the sky luminance was shown as 1:4, and against the walls of hiking path result was shown as 1:5. It appears that the buildings are, compared to the surrounding buildings, being appropriately emphasized against the background sight. Due to the low lighting installation of Chungpyunghwa located first to the west from the measurement point, it showed the difference of 45cd/㎡-12cd/㎡ when compared to surface luminance of southern buildings from three different places.

2) View 2
On View 2, Sinpyunghwa building is shown. The surface luminances are as followings; 55cd/m2 for the subject building, 0.3cd/㎡ for the sky luminance, 1.8cd/㎡ for the hiking path, 0.6cd/㎡ for the walls of the hiking path, and lastly 3.8cd/㎡ for the northern buildings. The luminance ratios of the buildings with the sky luminance, the walls of hiking path, and the northern buildings were respectively calculated as 1:140, 1:93 and 1:15. The northern buildings showed the luminance ratio of 1:13 against the sky luminance, 1:6 against the walls for hiking path. With the active use of outdoor lighting from Sinpyunghwa building, it displayed the highest surface luminance among the buildings.

3) View 3
On View 3, Pyunghwa building is shown. The surface luminances were as following; 37.1cd/㎡ for the subject building, 0.9cd/㎡ for the sky luminance, 3.2cd/㎡ for the hiking path, 1.2-1.8cd/㎡ for the walls

of the hiking path, and lastly 5.1cd/㎡ for the northern buildings. The buildings displayed the luminance ratio of 1:41 against sky luminance, 1:21 against the walls of hiking path, and 1:7 against the northern buildings. The northern buildings showed the luminance ratio of 1:4 against the walls of hiking path and 1:6 against the sky luminance. With the influence of the metal floodlight and non-neon advertisement installed on the rooftop subject, it is attributable to show the great luminance ratio with the surroundings was shown.

4) View 4

On View 4, Pyunghwa building is shown. The surface luminances are as followings; 22.0cd/㎡ for the subject building, 0.02cd/㎡ for the sky luminance, 0.8-0.9cd/㎡ for the hiking path, and lastly 0.4cd/㎡ for the northern buildings. The buildings displayed the luminance ratio of 1:1100 against sky luminance, 1:220 against the walls of hiking path, and 1:55 against northern buildings. The northern buildings displayed the luminance ratio of 1:110 against the walls of hiking path and 1:73 against the sky luminance.

6 CONCLUSION

It showed the luminance ratio in the range of 1:4.3~1:1100 against surrounding environment such as sky luminance, surrounding buildings, and the walls of hiking path in Cheonggyecheon. The signboard, entrance canopy, metal floodlight on the building edges and neon are actively used to visually emphasize the the building exterior.

The illuminations of the shopping complexes were strongly emphasized compare to the surrounding region at night. The buildings do not meet the harmonizing lighting situation with the stream and surrounded buildings. Luminance of the external walls with the metal floodlight and the signboards are exceeded to the CIE recommendation. It may cause excessive energy consumption and discomfort glare to drivers and pedestrians. For harmonizing the stream lighting, the illuminated surface of the shopping complex adjacent to the stream should be redesigned the high luminance and color of surfaces.

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RESIDENTIAL ENERGY EFFICIENT LIGHTING BY PROMOTING FLUORESCENT COMPACT LAMPS UNDER THE FRAME OF IEE PROGRAMME EnERLIn

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Keywords: Compact Fluorescent Lamps, Efficient Residential Lighting

1 INTRODUCTION

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 and domestic appliances and heating/air conditioning/hot water. The efficient use of electricity is still a neglected issue, with a lack of the necessary statistic data.

Market research has indicated that in order to substantially increase the use of CFLs in the residential sector, it is essential to develop and market attractive and good quality CFLs. The rate of the households owning a CFL covers the range 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. [1, 2] 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 [7].

2 EnERLIn - EUROPEAN EFFICIENT RESIDENTIAL LIGHTING INITIATIVE, supported by INTELLIGENT ENERGY EUROPE PROGRAMME

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 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. The European Union initiated numberless campaigns to promote compact fluorescent lamps with the purpose of increasing the market share of CFLs at 15%. 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. [9]

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 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). [6]. The residential sector represents 28% from the global electric lighting energy use. [7]

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. 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 CFL market share represents 20% of the global European market whereas the same figure in world scale is limited to 17%.

The ultimate objective of the EnERLIn 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. 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 final beneficiaries will be end-users of equipment mainly in domestic sector.

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). It should notice that the annual growth rate of the global lighting industry is in the order of 0.8%. [9]

EnERLIn consortium

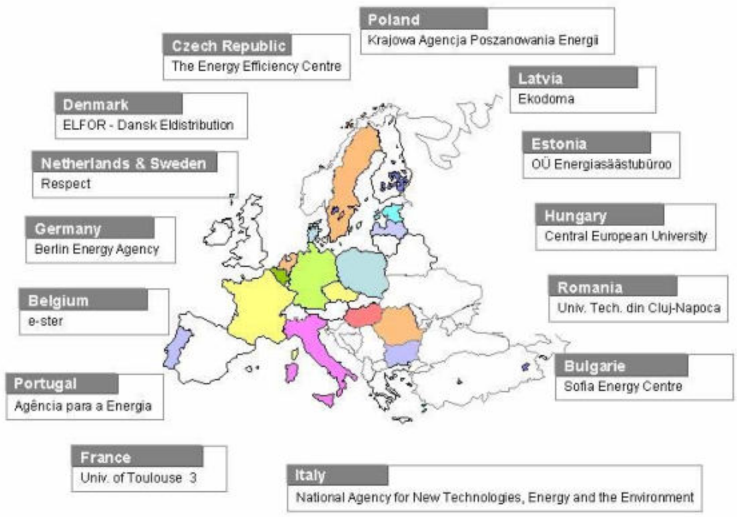

Figure 1 The EnERLIn consortium map

14 partners from 14 countries constitute the proposed consortium, covering a large part of the Europe form north to south and from east to west. This is an important issue; because, concerning lighting the reaction of the individual customers is quite different form a country to the other (north countries prefer low colour temperatures lamps, hot ambiance, and south countries are more sensitive to high colour temperatures, cold ambiance). The consortium includes western countries with high GDPs compared to eastern countries that they just integrated EU (Poland, Hungary, Czech Rep., Latvia and Estonia), and the newest EU countries (Bulgaria and Romania). The ENERLIN consortium is strongly cross-disciplinary including National or Regional Energy Agencies (ADENE, KAPE, ENEA, SEC, SEVEn, BE), one ESCO in Belgium, academic institutions (France, Hungary and Romania), a values-based consultancy focussing on sustainability (Respect) as well as independent consulting SMEs (Ekodoma, Energy Saving Bureau). Each partner has solid experience with EU projects (especially from DG TREN), and strong links with international organisms like CIE and projects like ELI, other European networks (COST-529) and programs (GreenLight). Some partners are quite influential for policy-making bodies in both national (regional) and European levels.

The **Romanian National Strategy in the energy efficiency field - 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 thermic insulation, the improvement of the heating and lighting systems and of the electric domestic appliances.

4 ANALYSIS OF ELECTRIC LIGHTING ENERGY CONSUMPTION IN THE RESIDENTIAL SECTOR IN ROMANIA

The statistic data [11] for the period 2000 – 2004 allow us to determine the variation of total household consumption, total number of household consumers, average consumption per household consumer, and of the specific consumption kWh/m^2 per year - Figure 2.

During November 2005 a preliminary 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 1–4 rooms - living room and bedrooms) and 75 houses (with 2–more than 7 rooms - living room and bedrooms). The light source equipment is presented in Table 1, and the average installed power - in Figure 3.

Table 1 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

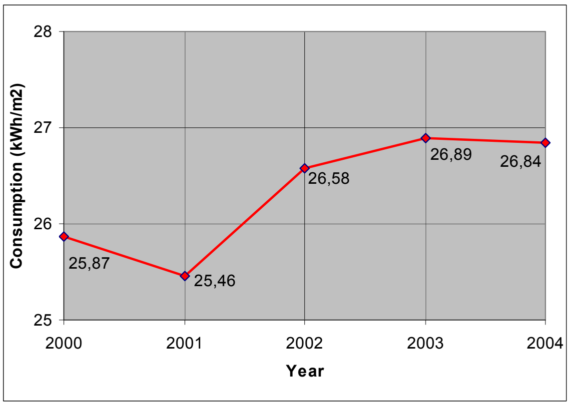

Figure 2 Household consumption per m^2 in Romania - [8, 11]

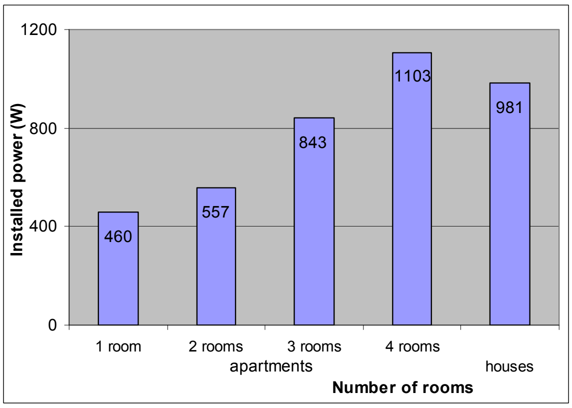

Figure 3 Average installed power in residential lighting - [8]

The analysis of the presented data allows us to estimate a few characteristics of electric energy consumption of households. The annual electric lighting household consumption in Romania in 2004 was about 6.83 kWh/m^2/year (based on the average consumption of 255.3 kWh/ household/year and average household surface of 37.39 m^2/household and the average contribution of the consumption on the lighting circuits - 25% according to the study [2]).

An introductory EnERLIN questionnaire campaign was promoted by two subcontractors of the project in November 2006, to have informative results for a better start of the Promotional Campaign on June - October 2007. This short campaign with 169 answers from the custom people of the electric equipment dealers pointed out that some questions from proposed questionnaires have to be changed, because they are without relevance or confused. An interesting result is related with the average number of the CFLs: 4.06 unit per people. It seems to be too great, mainly due to the fact that the questioned people known well the energy efficient lamps.

The further Promotional campaign will pointed compact areas – all households from a street with single family houses, a residential district of bloc of flats in a city, a county village.

CONCLUSION

The estimative 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, value that fit in the references limits. 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. [8] The predictable 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 both by users and by the electric energy providers, in order to reduce the consumption peaks that are specifically due to lighting.

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PUBLIC LIGHTING IN CITIES

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ABSTRACT

This paper is the result of a recent study of research in the area of urban lighting. The paper reviews a number of aspects of public lighting in cities based on a wide ranging survey of existing reliable sources of information. The paper discusses a number of the key benefits of good lighting in urban areas and provides information on the best use of lighting and shows that good public lighting can more than pay for itself in terms of reduced crime, fear of crime and road accidents. It goes onto discuss the way that lighting can change the way a city looks at night. It focuses on the way lighting needs to be structured to provide a pleasant atmosphere in city centres. The paper will also review some of the practical issues associated with city lighting.

1 INTRODUCTION

This paper is based on a recent review of publications dealing with the subject of urban lighting. Over 100 sources of information were reviewed and the basis of selection of any item for inclusion in this report was relevance, scientific rigor and the avoidance of duplication.

The subject of urban lighting is quite complex and there are many interrelated factors that need to be considered. In order to make the study manageable the material was split up into 3 sections namely Human Factors, City Image and Performance. These concepts are developed further in sections 2 to 4 of this paper.

2 HUMAN FACTORS

It is of fundamental importance that lighting is provided to meet the needs of pedestrians. There are a series of things that pedestrians rely on the lighting for, several researchers have made lists of the various needs, perhaps the best way of looking at these requirements was set out by Jones[1]. He considered that pedestrians had a number of tasks for which they needed lighting and he listed them as follows:

- Safe movement
- Visual orientation
- Visual comfort
- Facial recognition
- A general feeling of safety

Clearly there is a lot of interaction between these factors, for example according to van Bommel & Caminada[2] if the conditions are right for good facial recognition then a feeling of safety may be induced. The requirements for each of these tasks is explored in subsections 2.1 to 2.5.

2.1 Safe Movement

The amount of light needed for a pedestrian to be able to walk along a pavement is relatively low and the visual task is limited to detecting obstacles on the path. Many researchers have stated that a horizontal illuminance on the ground of less than 1 lx is sufficient for safe movement.

2.2 Visual Orientation

Orientation is achieved if pedestrians can recognise features in the environment and thus deduce their location and use this information to plan their route. In residential areas orientation is easy as most of the pedestrians are familiar with the area and so large objects such as houses and trees serve as landmarks. However, in city centres the layout is generally more complex and thus harder to read and the situation is made worse as many of the people using the area may not be familiar with the layout of the town. In such an area it is important to provide signage giving direction. Illuminance on vertical surfaces, particularly signs, is important in revealing the features and thus helping the process of orientation.

2.3 Visual Comfort

There are 2 aspects of visual comfort, one is the absence of glare and the other is related to the concept of pleasantness. Glare is a highly complex set of phenomena and it is common to split it into two categories disability glare and discomfort glare, and there are three methods of controlling glare given in the European Standard on Road Lighting[3]. However, some authors[4,5] have extended the concept of visual comfort to include a large number of other features ranging from the modelling of faces to the amount of light on buildings. Hargroves[6] developed the concept of pleasantness to describe a lot of these features. Pleasantness will be reviewed in more detail in the section on City Image.

2.4 Facial Recognition

The basic ideas about personal spaces were developed by Edward Hall[7] and he categorised the personal spaces around a person into intimate, personal social-consultative and public.

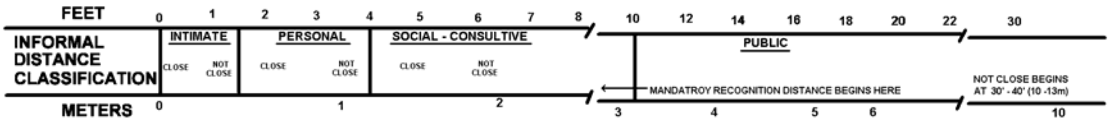

Figure 1 Hall's personal spaces

Figure 1 shows the spaces and the distances at which they occur.

Hall discussed the importance of these zones to people and why they felt uncomfortable with letting strangers entering their personal spaces (at distances of less than 3m) unless they recognise them. The importance of facial recognition to pedestrians was first reported by van Bommel and Caminada[2]. They used the basic ideas of Hall to explain why pedestrians at night did not like coming too close to other people that could not be recognised.

They proposed the use of the criterion that street lighting should permit the recognition of a face at a distance of 4m. van Bommel and Caminada then went on to establish that semi-cylindrical illuminance on a person's face was key to them being recognised. Further research[5] confirmed van Bommel and Caminada's findings.

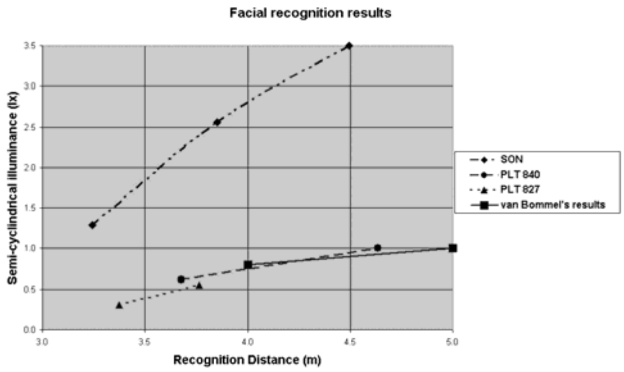

Figure 2 Facial recognition distance with different light sources (from Raynham[8])

More recently Raynham and Saksvikrønning[9] used facial recognition as a tool to compare the efficacy of different light sources; Figure 2 shows some of their findings.

The key finding from the work of Raynham and Saksvikrønning was that white light with a good colour rendering (Ra 80) is much better for facial recognition than light with low colour rendering from sources such as high pressure sodium lamps. On Figure 2 data is also plotted showing the results of van Bommel and Caminada, their values closely follow the data for white light sources. It was subsequently discovered that they had used white light sources with a Ra of 60. Recently the finding that white light is better than light from HPS lamps has been confirmed by Knight, Kemenade and Deveci [10]

2.5 A General Feeling of Safety

Many researchers[1,2] have argued that lighting can promote a general feeling of safety. However, feelings of safety depend upon a lot of factors other than lighting. Boyce et al[11] conducted a study in areas of New York City and Albany that showed that in general the greater the amount of light provided by the greater the feeling of safety. Analysis of the experimental findings also revealed that,

in general, men felt safer than women. The difference in sense of safety was also found by Mansfield and Raynham[12] who, additionally found that older people felt less safe than young people.
Boyce's study also looked at a series of car parks in Albany and compared the feeling of safety during the day and at night. In all cases he found that people felt safer during the day. Moreover, he was able to relate the change in the feeling of safety between day and night to illuminance at night, the higher the illuminance the less the change in feeling of safety. Figure 3 shows the findings of Boyce's study where subjects were asked to rate the feeling of safety that they had whilst walking in particular car parks during the day and at night, the difference in the day and night scores were then plotted against the night time illuminance.

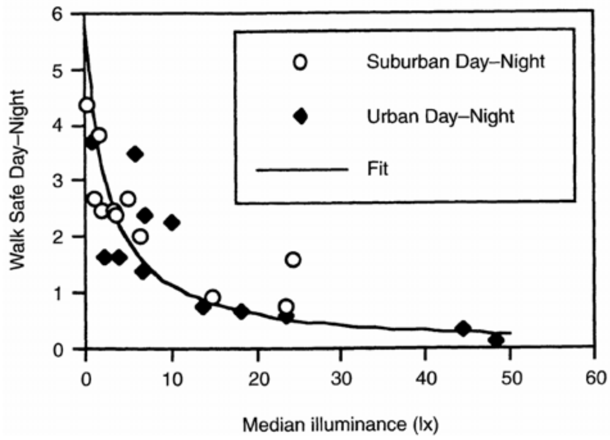

Figure 3 Difference in mean ratings of perceived safety day and night (day-night) plotted against mean illuminance

The main factor working against a feeling of safety is a fear of crime. Fear of crime is a very complex phenomenon that is only loosely related to the risk of being a victim of crime. For example, Raynham and Gardner[13] found that young men were many times more likely to be victims of crime than old ladies, however, their fear of crime was much less. In some instances fear of crime and crime itself are related. Painter and Farrington[14] found that good street lighting reduced the amount of crime; in fact they were able to establish that the cost saved by the community in one year from reduced crime was greater than the cost of installing the new lighting system.

3 CITY IMAGE

A modern city comprises a complex network of roads, buildings and open spaces, thus at night it is essential that the city is appropriately lit. This lighting should aid orientation and provide a feeling of safety to pedestrians; moreover, the lighting should provide a stimulating environment. In order for the lighting to fully meet the needs of acity several issues need to be addressed these include amenity, planning and iconography.

3.1 Amenity

Hargroves[6] studied a number of town centres and concluded that people ranked highest, those schemes that had a good general uniform illuminance coupled with visual accents provided by highlighting certain features within the environment, such as trees and statues. He concluded that for town centres there should be:

- There should be an overall coverage of light of not less than 20 lux average on the horizontal (E_H) with a uniformity as high as 0,3 (6 lux minimum) and not less than 0,1 (2 lux minimum)
- The average illuminance (E_V) on vertical planes 1.5m above ground, provided by the overall coverage should be greater than $0.8E_H$ average (16 lux E_V) with a uniformity of not less than 0.2 (3.2 lux min E_V)
- Accent lighting should be used to highlight particular features e.g. statues, waterfalls, seating, shrubs, entrances, etc. Such lighting should provide an illuminance on a vertical plane of 5 Lux (E_V).

He also said that in shopping precincts, the amenity value is enhanced by having shop windows lit and where decorative luminaires are to be used as accent lighting, they should aim to create sparkle whilst not causing glare.

3.2 Planning
The key to a successful urban lighting scheme is good planning. Lighting should providing good amenity, ensure safety and sense of well-being; but more importantly it must be well integrated within the existing urban fabric. In 2002 a number of cities got together to form "Lighting Urban Community International" (LUCI)[15] to provide a forum where cities can compare experiences and share skills associated with urban lighting.

Urban lighting should identify the different zones of a city and how people interact with these elements. Kevin Lynch[16] in his book 'The Image of the City' identifies certain areas within the network of routes that make up the urban landscape. These are nodes, landmarks, district edges and paths. Nodes are areas where there is convergence or a change in movement, or place of physical character such as a square or street corner.

It is therefore important to identify these areas within the urban fabric and address the issue of lighting accordingly. These areas could also be broken down into their level of use, main function and level of importance. For example, a main thoroughfare could be described as HIGH, TRANSITORY and MAJOR whereas a small residential street square might be described as LOW, SOCIAL and MINOR. This grading not only aids in the provision of a suitable solution appropriate for the area and the level of use, but also ensures that amenity is appropriately provided for.

In a similar approach, Takada & Higo[17] describe a concept for the lighting of roads in and around residential areas of Tokyo with the emphasis on the pedestrian rather than the motorist. The concept is based on two points.

1. There must be no "dangerous darkness" in any part of the residential area.
2. With priority given to pedestrians' actions, a "walking space axis" of the main roads used by pedestrians must be clear.

Areas were divided into certain categories, main roads, and introductory roads to residential areas, pedestrian distributor roads and access roads. They also identify significant points of pedestrian movement such as bus stops or railway stations. The main routes with multiple pedestrian and vehicle junctions were illuminated to a higher level due to their higher volumes of traffic and increased level of danger. So, too, are major junctions and areas such as bus stops. Slowly the level of illumination is reduced until a minimum safety level is provided in the subsidiary access roads. This approach also aids the guidance of pedestrians via differences in illuminance levels. This approach was tested in 5 adjoining residential areas of Tokyo. First, a bright road axis was created with an illuminance of 20 lux for the main roads, with a lower level of 8 lux for distributor roads and 1,5 lux throughout the rest of the blocks. Pre-and-post experiment testing was carried out focusing on the subjective evaluation of brightness and facial recognition. The study reported that recognition in the area was made easier and the perception of brightness increased.

3.3 Iconography
A city lighting strategy should enhance key features of the city by night. Often central to the city lighting plan is a river running through it. Babou[18] found that these vistas usually dominate the night time image and create iconic views of cities. In London care was needed in lighting the riverside to ensure the correct balance between the historic buildings and bridges, and the more modern structures in the area . Babou also reports that all the historical monuments studied, are lit in accordance with the recommended levels[19], with the exception of Tower Bridge with a higher level of luminance $25cdm^{-2}$. However, this is a very important landmark by day and night and therefore the higher level is justified by the upper hierarchy level that Tower Bridge occupies.

4 PERFORMANCE

When installing lighting there are always a number of issues to consider relating to the practical implications of the lighting system, this section looks at some of those issues.

4.1 Energy
Street lighting is a significant user of energy, for example in the UK, street lighting accounts for about 1% of all non-domestic electricity use. However, it must be remembered that in the UK the vehicles using the road emit 62 times as much carbon dioxide as used to generate the electricity that powers the street lighting. Thus in urban areas that are well lit, it is possible that the street lighting reduces overall CO_2 emissions by encouraging people to walk or cycle. For example, consider a residential road, illuminated to 10 lux average (horizontal) using a 70w SON lantern with a typical mounting height of 5m will achieve typical column/lantern spacing in the region of 30m. Considering a 1 kilometre stretch of road

approximately 33 lanterns will be needed, each with a typical total circuit energy consumption in the region of 83 watts, thus giving a total energy consumption of 2,739 KW producing 1,7 kg of carbon dioxide emissions per hour. A typical super-mini car will produce approximately 0,13 kg of carbon dioxide emissions per kilometre. This is further increased with less efficient cars, for example a medium sized car produces approximately 0,25 kg of CO_2 per 1km, with the worst offenders, super-cars, producing in excess of 0,5kg per km[20]. Thus it only needs only a few extra people deciding not to drive for the street lighting to have the net effect of reducing CO_2 emissions.

4.2 Light Pollution

Lighting at night can cause problems when light becomes obtrusive. There are a number of guidance documents[21,22] available to provide advice in avoiding the various forms of nuisance that lighting can cause. To make matters more complex some countries have laws to control light pollution. For example, in the UK Clause 102 Clean Neighbourhoods and Environment Act 2005[23] made it a criminal offence for 'artificial light emitted from premises so as to be prejudicial to health or a nuisance'.

4.3 Traffic Accidents

Road accidents are a major cost to the community. Table 2 below gives the costs for road accidents in the UK.

Table 2 –from 2005 Valuation of the Benefits of Prevention of Road Accidents and Casualties[24]

Costs of Road Traffic Accidents In UK (£ June 2005)				
Injury severity	Lost Output	Medical	Human cost	Total
Fatal	490,960	840	936,380	1,428,180
Serious	18,920	11,460	130,110	160,490
Slight	2,000	850	9,530	12,380

Typically about half of all fatal road accidents occur during the hours of darkness and given that the traffic at night is only about one third of that by day this represents a huge increase in risk at night. In the UK during 2004 there were 3221 people killed and 34,351 seriously injured. Work by the CIE[25] studied road accident data in a number of countries and came to the conclusion that road lighting reduces accidents at night by 30%. Given the large number and high cost of accidents the money saved by accident reduction is significantly greater than the cost of maintaining and running the street lighting.

5 CONCLUSION

To sum up good lighting can transform our cities at night and provide a visual environment where pedestrians are happy to use the streets. It can save the community money by reducing traffic accidents and crime. In some circumstances it may even reduce CO_2 emissions.

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GREENLIGHT IN ROMANIA

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ABSTRACT

The European GreenLight programme is an on-going initiative from the European Commission whereby voluntary organisations commit to adopting energy-efficient lighting measures when these are profitable and maintain or improve lighting quality. At the time of this writing, 93 public and private organisations have signed the GreenLight partnership. Major players have joined the movement and several GreenLight upgrades have got off the ground. Given its success, the programme was extended in 2002 to the Candidate Countries, including Romania where the Romanian Agency for Energy Conservation (ARCE) has agreed to act as Greenlight National Contact Point. ARCE has volunteered to promote the programme and enrol the first Romanian Partners.

INTRODUCTION

The GreenLight programme is an on-going voluntary programme whereby private and public organisations (referred to as Partners) commit to adopting energy-efficient lighting measures when (1) the cost of these measures is repaid by the associated savings[1] and (2) lighting quality is maintained or improved. In return for their commitment, not only do these Partners benefit from the savings, but they also receive broad public recognition for their effort in protecting the environment.

The GreenLight programme started in 2000 upon the European Commission's initiative (EC), with support from the national energy agencies of 13 Member States, plus Norway (NOVEM 1999). At the end of 2002, the programme was opened to the Candidate Countries, including Romania where the Agency for Energy Conservation (ARCE) agreed to promote the programme.

The objective of this paper is to introduce the GreenLight programme to potential Romanian Partners, showing them some pertaining GreenLight success stories.

WHAT IS THE GREENLIGHT PROGRAMME?

The GreenLight programme helps voluntary non - residential electricity consumers (public or private), referred to as Partners, save money and reduce pollution by increasing the energy efficiency of their lighting. The core of the programme is a Registration Form, signed by the Partner and the Commission, in which the Partner commits to:

For existing spaces:

Either upgrade at least 50% of the spaces owned or on long term leases (5 years or more) where the investment is profitable or, alternatively, reduce the total aggregate lighting electricity consumption by at least 30%.

For determining if an energy-efficient lighting investment passes the profitability test, the Partner can choose either to use as criterion (1) an Internal Rate of Return[2] (IRR) of 20% calculated over a period of 15 years or alternatively (2) the Least Life Cycle Cost rule over the project's lifetime (minimum 5 years).

The least Life Cycle Cost rule consists in accepting an energy-efficient lighting investment when the resulting Net Present Value[3] (NPV) of the investment is above or equal to 0.

For new spaces:

New installations must be chosen so that no alternative installation exists that would:

- maintain or improve the lighting quality provided by the chosen installation and

[1] GreenLight applies to 50% of the eligible upgrades. Eligible upgrades are those yielding an Internal Rate of Return above 20%.
[2] The Internal Rate of Return is the interest rate that equates the present value of expected future cash flows to the initial cost of the project. Expressed as a percentage, IRR can be easily compared with loan rates to determine an investment's profitability. For a stream of equal cash flows, an IRR of 20% over a 15 - year period corresponds to a payback time of 4.7 years.
[3] The Net Present Value is the total cash flow that the project generates over its lifetime, including first costs (counted negatively), with discounting applied to cash flows that occur in the future (money savings, counted positively).

- consume less electricity and
- represent a supplementary investment for which the Internal Rate of Return would exceed 20%.

In addition, the Partner shall:

- complete the upgrades within 5 years of joining the programme and
- send a progress report every year (simple one-page form) and
- appoint a Corporate Manager responsible for assuring the Programme execution.

Companies preferring to join the programme only for a specific site(s) can do so. More sites can be added to the company commitment and it is always possible to move from a site partnership to a corporate partnership or vice versa.

The GreenLight Programme encourages its Partners to tap a large reservoir of profitable investments without the need for specific incentives from the Commission. GreenLight investments use proven technology, products and services which efficiency has been demonstrated. The Commission provides support to the Partners in the form of information resources and public recognition: plaques on building, advertisements, exclusive use of the logo (see figure 2), and awards.

The GreenLight logo (only to be used for official GreenLight use, with prior permission from the European Commission)

Lighting professionals interested in promoting GreenLight and assisting its Partners are encouraged to register as GreenLight Endorsers. In return, the Endorsers get public acknowledgement for their efforts to support the GreenLight Programme.

Joining the GreenLight Endorser Programme proceeds through a Registration whereby the registrant agree:

- to appoint a responsible person;
- to promote the GreenLight Programme and its goals;
- to supply the Commission up-to-date information on its products, technologies and services relevant for the GreenLight Programme;
- to educate its clients on the benefits of energy-efficient lighting practices and on the GreenLight Programme;
- to lay out a specific plan for promoting the GreenLight Programme.

The full description of the Partners and Endorsers obligations, as well as the GreenLight information resources, are available on the GreenLight web site at www.eu-greenlight.org.

PROMOTION OF ENERGY EFFICIENT LIGHTING IN ROMANIA

Legislative framework

In Romania, the Law 199/2000 concerning the Efficient Use of Energy sets the national policy for the efficient use of energy. It forms an integral part of the energy policy of the State, based on the principles of a competitive energy market, environmental protection and co-operation between consumers, producers, energy suppliers and public authorities.

The Law 199/2000 was adopted by the Parliament in October 2000 and subsequently revised by Ordinance no. 78/2001. Its main objective is to increase the efficiency of the energy chain from production, conversion, transport, distribution to final consumption of energy.

This Law defines obligations for energy users with an annual consumption above 1000 toe and for municipalities with more than 20000 inhabitants to develop energy conservation programmes. These programmes shall include both short-term low-cost measures and long-term actions, with a 3-6 year energy efficiency investment plan.

Beside that Law, two important Community directives related to energy efficient lighting were transposed into Romanian legislation:

- directive no. 98/11/CE with regard to energy labelling of household lamps by Romanian document HG 1056/2001 published in MO 727/15 11 2001
- directive no. 2000/55/EC on energy efficiency requirements for ballasts for fluorescent lighting by Romanian document HG nr. 1549/18.12.2002 published in MO 20/15.01.2003

These legislative documents have created an appropriate framework for the promotion of new technologies in the lighting sector especially through low- or medium- cost projects.

This framework has been consolidated from the change in the Romanian energy pricing. In the past, energy prices in Romania were subject to subsidies and cross-subsidies. In the electricity sector, direct cross-subsidies between household and industrial consumers were eliminated in 1999 and cross subsidies between electricity and heat were eliminated in 2000.

IMPLEMENTATION OF GREENLIGHT IN ROMANIA

The extension of GreenLight to Romania was decided on December 2002. The National Contact Point (NCP) for the programme is the Romanian Agency for Energy Conservation (ARCE)[4]. ARCE joined the European network of GreenLight national contact points. The GreenLight NCP have formed a cohesive network which has gained knowledge and experience in promoting energy-efficient lighting. The NCP have provided a direct feedback on the appropriateness and effectiveness of the GreenLight approach and tools. Their involvement has enabled GreenLight initiators to pool available expertise in order to enhance the quality of the GreenLight information resources.

ARCE is marketing the programme to enroll the largest number of Romanian companies. Building on the lessons learned by the other NCP (EC 2002), they will first target those which are highly visible and those with the most forward and publicly stated environmental policy. To the most reticent, they will propose to enrol first in a GreenLight pilot, and then investigate signing up for the corporate GreenLight commitment. This marketing strategy proved to be successful in other countries. Whatever the company, they will try to identify a champion who can play a decisive role in prompting the company to adopt energy-efficient lighting practices. A reliable contact name within the organisation has indeed shown to be of vital importance for success. ARCE will also maintain contacts with relevant networks and interest groups with the idea of enlisting them to promote GreenLight to their members.

Along the same line, they will assist the EC in providing public recognition to the GreenLight Partners. They will have a key role in awarding particularly progressive Partners and Endorsers. They will also ensure liaison with the national media and be entitled to deliver the GreenLight plaque. The plaque was designed to allow Partners to show their responsible entrepreneurship to their clients.

From a technical point of view, they will help the European Commission monitoring the GreenLight Partners' achievements in Romania. They will also help the EC tailor the GreenLight web site for Romanian partners (http://www.eu-greenlight.org). Beside raising public awareness about energy-efficient lighting in general, this web site is designed to be the main information centre of the European GreenLight Programme. It is to be used as one of the central promotional vehicles of this Programme and as a "virtual" backbone for all GreenLight activities.

THE RESULTS OF GREENLIGHT PROGRAMME IN ROMANIA

The aim for Romania in GreenLight programme was to reduce the electrical consumption with min. 6,21 /1,86 GWh. The result is, up to now, 20,56/44,557 GWh.

These results were obtaining with the contribution of the partners and endorsers wich are:

- the partners from Romanian accepted in GreenLight programm are: Romanian Chamber of Deputies, Metrorex S.A., PAN Group Craiova, Eurogara Drobeta Turnu-Severin, Plaza Hotel - Craiova, Energobit SRL, CRAIOVA Railway board branch , Hunedoara City Hall, Marghita City Hall, Bacău City Hall, Focşani City Hall, Piatra NeamT City Hall, Salonta City Hall, and University of Oradea.

- the endorsers accepted from Romania are Energolux SRL and Lighting Engineering Center UTC-N.

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[4] ARCE is based in Bucharest and it has 15 territorial branches in Brasov, Cluj, Constanta, Galati, Iasi, Suceava, Timisoara, Oradea, Craiova, Deva, Targu Mures, Sibiu, Ploiesti, Bacau and Bucharest also.

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ARTIFICIAL LIGHTING: HEALTH, ENVIRONMENT AND WELL-BEING

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Nobody can doubt seeing the picture of the figure 1 that corresponds to a city of our days. The intense use of the Artificial Lighting has become a definitive sign of our time. Every night, when the shade begins to invade "the dark face of The Earth", the brightness of our cities manifests the existence of the human being. (Figure 2)

Figure 1

Figure 2

It is a very recent phenomenon to historical scale, unthinkable few decades ago whose complexity and significance hides under the apparent simplicity of "to switch on" and, with this simple expression, to have all the light that we need, doesn't matter the place and doesn't matter the hour of the day. However, it is a phenomenon that, at least for us - lighting professionals - deserves attention; we cannot avoid to think about it

Historical evolution of the Artificial Lighting

The flame, under its three classic forms: torch, oil lamp and candle (Figures 3-6) has been the instrument of the humanity's lighting from the most primitive times of the prehistory.

Figure 3

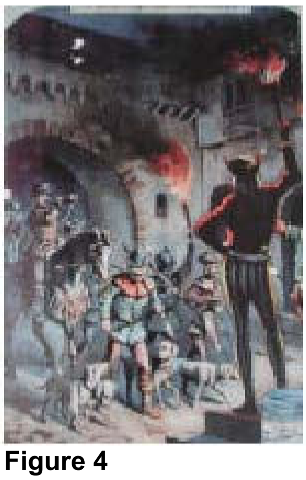

Figure 4

Figure 5

Figure 6

These Lighting Systems have remained without substantial variations from their beginnings until the XIX century. The cause of it, has possibly to be search in the scarce social demand of lighting; the main and majority activities were developed outside and during day hours: the natural light provided the necessary visual conditions. The combustion lighting, in spite of their weakness and intrinsic defects (mobility of the flame, heat, smoke) was enough for the marginal functions that were assigned.

But the social changes results of the Industrial Revolution gave origin to two phenomenon that invalidated this situation:

- concentration of the activities in areas of easy accessibility to the necessary energy for the production; namely: intensive use of the territory, instead of the previous extensive use.
- prolongation of the periods of activity to accelerate the amortisation of the capital invested: the night, 50% of the available hours, could not be wasted.

Both demands are impossible to satisfy only using solar light, so that the development of the Artificial Lighting Systems took, first time in the History, a strong impulse.

The first intents were aimed at the improvement of the classic systems, in a large part of their fuels: use of paraffin, oil…Appears also the use of gassy fuels: acetylene, hydrogenate, oxhidrica mixtures, distillation gas (called in that time, in fact, “lighting gas”)… A first qualitative springboard goes with the introduction of the “lime light” in the lighting for gas and oil: for first time in the history is no longer the flame the direct luminous source, but an intermediate element took to the condition of “incandescence.”

Figure 7

Figure 8

The same thing happens in the lighting of voltaic arch -spark generated between two electrodes of coal -. In addition that the primary energy was no longer chemical, accumulated in the matter, but electric: potential difference among the ends of a conductor, generated by the flow of electrons along thesame one.

This electric power is the one that investigators as Davy, Goebel, Swan etc. use, and the one that in 1879 allows to T. A. Edison to starting-up the first “electric lamps.” Although the current perspective seems to indicate an easy distance from the “electric globe” to our current Systems, the reality didn't turn out to be so simple. Considering the proximity and transcendence of this period, perhaps it could be convenient to make a “zoom” of attention and detail on the XX century in this accelerated description.

Figure 9

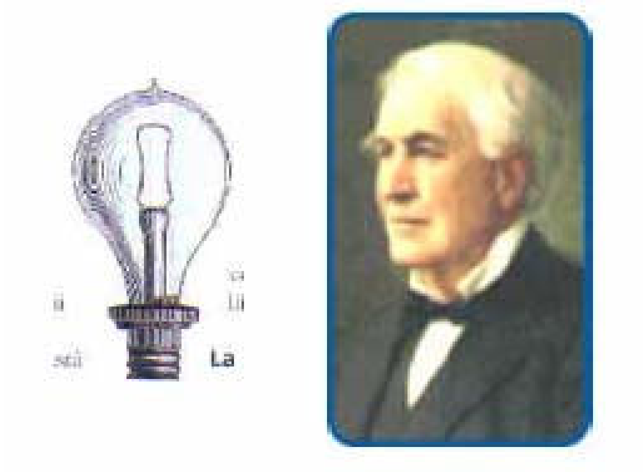

Figure 10

The Artificial Lighting in the century XX

Although at the beginning of the century the lamp of incandescence had twenty years of diffusion, during their first decades the electric lighting had to compete with the combustion systems. The limitations of extension of the feeding nets were one of the reasons that hindered their expansion without a doubt. But another of the causes has to attribute to the limitations characteristic of the electric lighting of those times. Anecdotally, the defenders of gas lighting manifested that “it was necessary to light a match to check if really the filament of a bulb shined.” They mentioned with it to the scarce power of the lamps, to the anomalies of electric supply, to the excessive mortality…

Figure 11

Figure 12

Figure 13

In spite of these weaknesses-that, although exaggerated in the anecdote, they were real such an extent that today would amaze us, the electric lighting achieved territory and enlarging its applications in the process that would lead him until its current hegemony.

The inflection point that marks the beginning of the Artificial Lighting just as today we conceives it, takes place before half of the century, near the year 1940. The development of the war industry of North America is conditioned, because the most part the labour population was militarised, by workers from other areas with more demands regarding the conditions of its working environment. It also coincides in this period the growing influence in the industry of psychosociologic Elton Mayo's theories that progressively substitute the precedent taylorist outlines. Everything leads to a substantial increment of the habitual Levels of Lighting – remember the Hawthorne experiences -, and the introduction of Visual Comfort concepts.

Figure 14

Figure 15

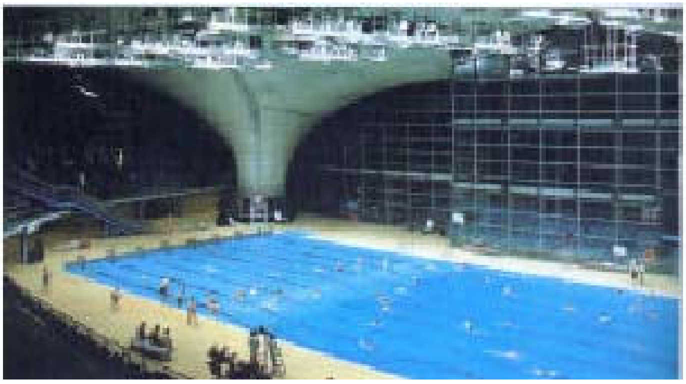

Figure 16

From the point of view of the Systems of Lighting, the author of this transformation is the fluorescent tube, with its larger effectiveness, reduction of shine and adaptability of the light tonality . It marks the “star shoot” in a career toward the diversification of luminous sources, increments of effectiveness and power, design of optic systems… until reaching the wide current range of possibilities and, with it, the spread of the Artificial Lighting in types of applications, as well as in their extension and in the qualitative increment of their benefits.

This way, leaving of an initial situation where the lighting demand had to surrender to the limited bid of the existent Systems, we arrive at last decades of the century to have a variety and quality of possibilities that allows to affirm that any desirable light situation is - at least in theory-potentially feasible.

Figure 17

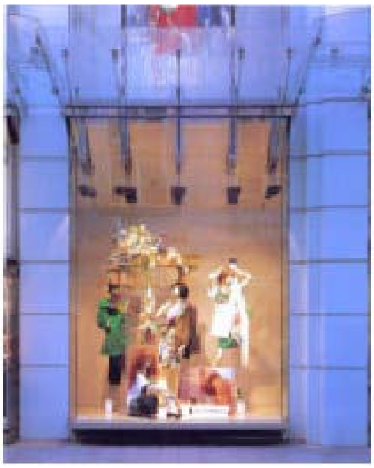

Figure 18

The offer has ended up overcoming on demand, but it doesn't stop in its simple satisfaction: it stimulates it toward higher marks, it extends the requirements of utility and comfort with those of satisfaction, it moves activities (for example: sport) toward the night hours to let enjoy of them, or in other cases to profit the image appreciation that a spectacular lighting can provide them.

Figure 19

From the use of the oil lamp a few minutes of the day, from the shy lighting inside the churches, we have passed to a world where the artificial light switch on when the alarm clock sounds, it floods the labour life, the trip, the social and entertainment relationship, and it only turn off when we retire to the dream.

In the XXI century

It is certain that the trajectory of the Artificial Lighting described previously has provided big benefits to our society. It has enlarged our time, since it allows to prolong the activity at the night hours, it has extended our space, since it allows us the use of interior spaces-even underground -, and it has improved our quality of life, since it allows us to create the good visual conditions for our activity and wellbeing.

The Artificial Lighting is technically a energy transformer system, which processes starting from a primary form-chemistry, thermal, electric… -generating electromagnetic radiation. But an important proportion of this radiation is necessary to be emitted in wavelengths inside the visible spectrum, since its purpose is not energetic but informative. The interaction of this radiation with the objects and spaces has to be able to stimulate the receivers of the human retina, activating this way the process of visual perception that, in the great majority of cases, is indispensable so that the observer could carry out his activity.

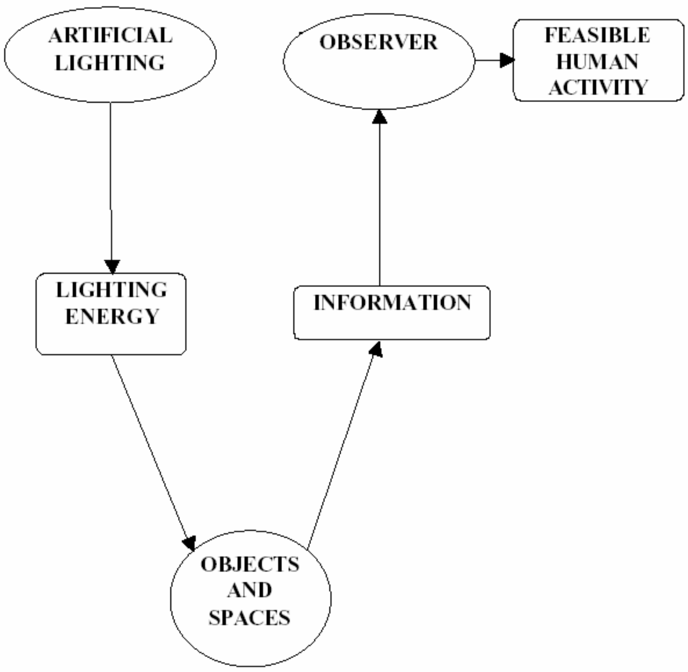

Diagram 1

The great contribution of the XX century has been the quantitative and qualitative improvement of this process, in such a form that, while previously we only were able to generate the necessary visual conditions to do the activities feasible, today we can contribute with the Artificial Lighting to improve its yield, quality, security and satisfaction.

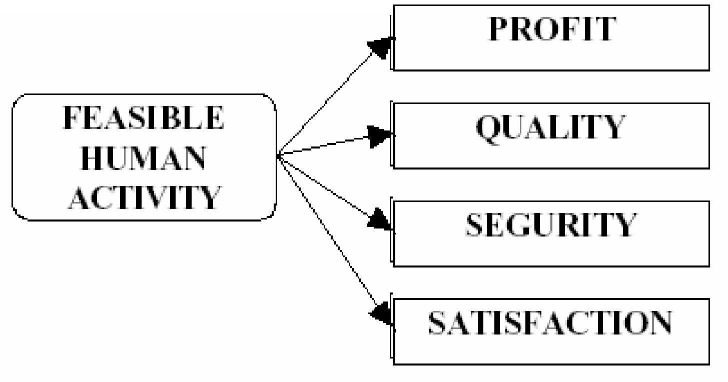

Diagram 2

It explains that our society is immersed in an extensive and intense use of the Artificial Lighting whose panoramic express perfectly the vision of our planet from the space.

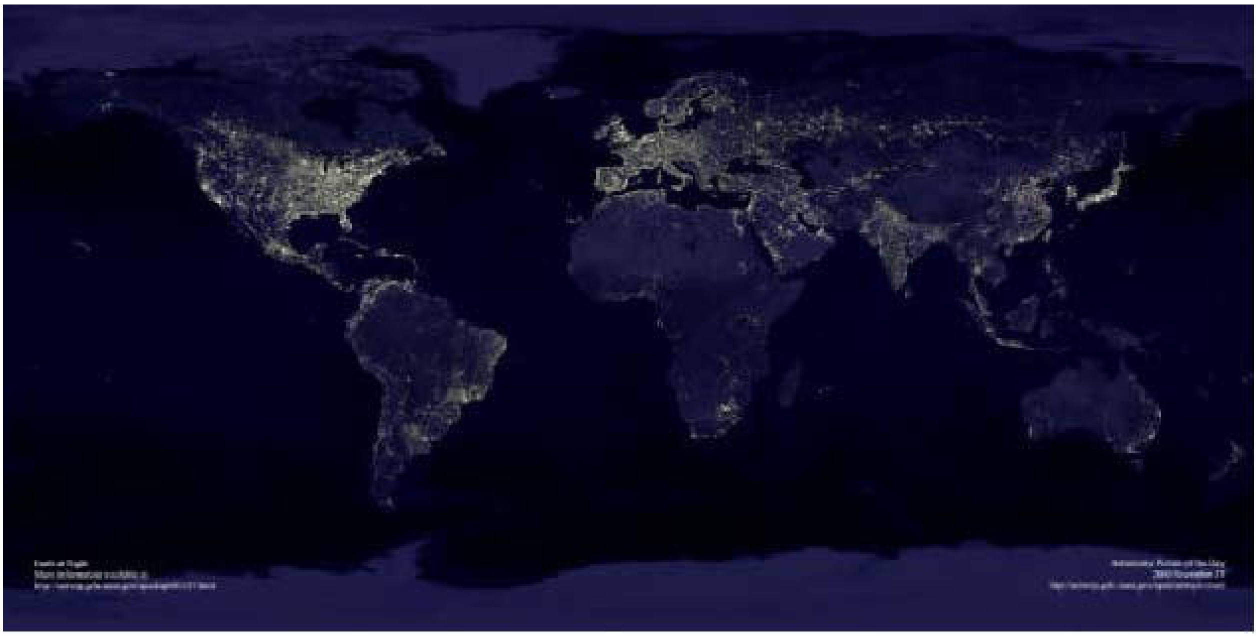

Figure 20

(Tangential interlude:
Not confirmed informations assure that the Martian scientific community has taken advantage the period of maximum approach of both planets in August of 2003 to thoroughly study the strangers night emissions of the Blue Planet of electromagnetic radiation in wavelengths in the area between the 300 and 700 nanometers.

It seems that two hypothesis remains divided the scientific community, and they are object of having inflamed discussions in the Congresses, without until the moment none of them has been able to contribute conclusive tests in its side.

The first hypothesis outlines the existence in the atmosphere of the Blue Planet of significant proportions of mercury and sodium steam that would be activated by potent electric storms. Their opponents find inexplicable the temporary and geographical regularity of the phenomenon in addition to the analyses spectrographics of the atmosphere carried out during the day don't confirm such composition.

The second hypothesis is based in the existence in the Blue Planet of some species of primitive beings that would take advantage of the nights to communicate with its gods by light offerings. The opposes to this theory consider that, of existing a similar species, it would necessarily have reached a minimum grade of intelligence, while all the remaining available data confirm the total absence of this quality in the Blue Planet.)

Figure 21

If this vision carries out it with more vicinity that an artificial satellite-and don't say a Martian observatory-we can check that the logical use of the Artificial Lighting, encouraged by the benefits that have been mentioned before, produces, given its intensity, a phenomenon of “overflow.” The light doesn't stay in the homes, in the streets, in the places of work… this accumulation of particular uses, invades the general space: the light invades the environment.

And when to final of month we have to pay the electricity invoice, we can deduce that, that same environment that we invade, we extract the necessary resources to have that light.

The outline suggested previously is certain, but incomplete. It forgets that the useful functions of a process always go accompanied by parasitic functions, not wanted but indispensable for the operation of the System. It forgets the necessary resources for the operation, and the residuals generated by the same one.

Consumed resources and generated residues

The previous diagrams express the “lighting intention” and it must to be completed with the “lighting necessity”.

Our action is not “costs free” and have “consequences”; in order to realise our function we have to consume material, energy and also informative resources, understanding the last ones not only as technical or scientific knowledge, but also as a “qualitative demands and judgements” , what we call “culture of the light”, whose conceptions shape our proposals and they condition answers of the artificial lighting users. Generated residues also takes the three forms: material (lamps, equipment... at the end of their useful cycle of life), energetic (heat, UV and electromagnetic radiation, non optical effects...) and informative (intrusion and light pollution, landscape intrusion...).

I think most of the lighting technicians would agree that our discovery about this “tangential” aspects has been passive: this aspects have been going imposed as the problem got importance and magnitude. Maybe the beginning is in 1970 when the rise in prize of energy, because of war reasons, concerns the sector about energy efficiency; it is only necessary to analyse the Lighting Congress rates before this date and after it, in order to check this inflection point. Even though the discovery has been passive, the answer has generally been “defensive”.

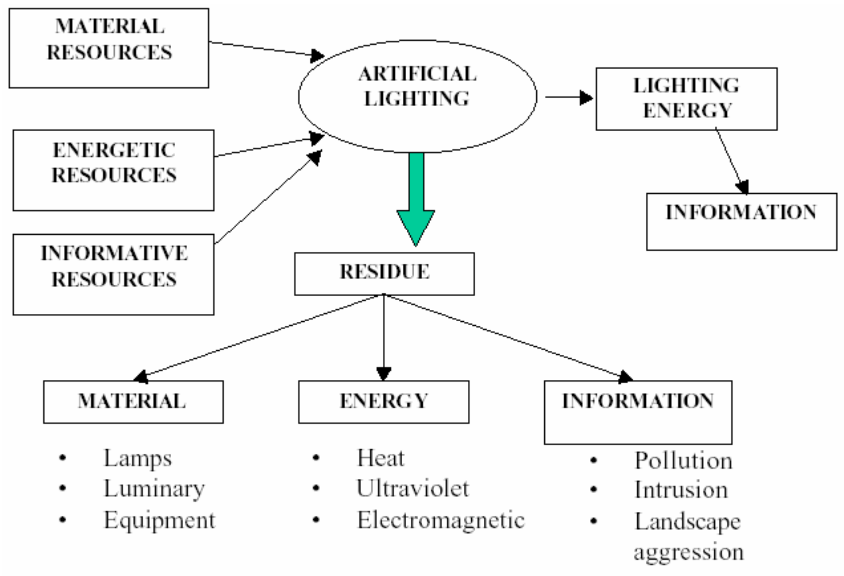

Diagram 3

The brief historical description done before has shown us the XIX Century as time of Artificial Lighting birth in its current conception, and the XX century as time of its development. If the XXI century wanted to be the artificial lighting maturity, it would be necessary to substitute this “passive and defensive” approach, for an active and constructive attitude that allows to anticipate the knowledge of the possible problems and also allows to focus on the outlines that can avoid them or, at least, decrease them. The starting point can be the analysis of critical aspects that nowadays is already possible to know, critical aspects that affect to the environment, the human health and the equality.

Environmental repercussions of Artificial Lighting

As it is already known they point in tree aspects:

- **Energy consumption**

  The energy consumption have an effect on environmental problem through:
  - ✓ The non-renewable natural resources consumption
  - ✓ The emission of pollutants
  - ✓ The environment degradation

The whole Artificial Lighting represents a very remarkable percentage from total energy consumption of our society. The estimate changes depending the countries or study methodologies, but all of them were near 2000 Twh at year 19971, and its volume doesn’t stop to increase in spite of the great improvements in systems efficiency.

It should be pointed out, also as a general feature, that real energy efficiency of the artificial lighting equipment is far away from its potential value. An example of it is the percentage of incandescence lamps use, which an efficacy about 10-15% with respect to other types, reach a market share between 80 and 90%.

HIGH GROWING RATE

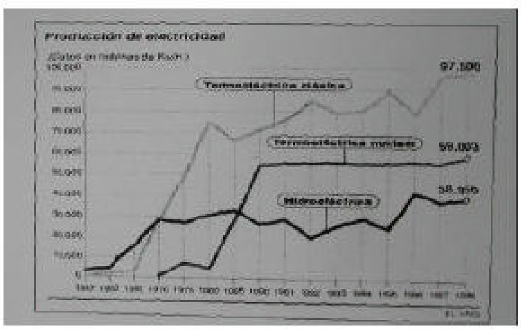

Diagram 4

- **Generation of residues**
  The specify problem of Artificial Lighting is in two aspects:
  - ✓ he environmental noxious materials (mercury, strontium, lead, strange land...) generally included in the electric lamps composition. Moreover, the lamp is the most lasting element of the equipment, its frequent reposition increases the wastes generated.
  - ✓ The increasing use in the ballast or other electronic elements with their specific elimination problems.

The treatment of these wastes is difficult and expensive. On the other hand, it must be pointed out a notable effort of the industry in the reduction of these components in the products.

Figure 22

- **Light pollution**

The light emission in direction that are not necessary for its function (sky glow, intrusive light…), produce the following effects:

- ✓ It invades natural spaces and modify conditions of alive beings' environment and affecting, therefore, their feeding habits,reproduction, migration, etc… with consequence threats to the ecological balance.
- ✓ It increases the dark sky luminance decreasing the contrast that let appreciate stars, with scientific purposes, amateurs or simple personal view.
- ✓ It invades human habitat being able to cause trouble for the night rest, intimacy, night experience, etc. In some urban areas, children already define yellow as the colour of night sky.

Figure 23

[1] Evan Mills, Ph. D – Right Light 5. Nice 2002.

To this effects must add that all this light dispersed in the atmosphere needs to produce it an energy consumption that, instead of a functional using, it causes troubles. It is a really counterproductive consumption instead of an energy waste.

Any of these aspects could be developed with more details and specifying concrete consequences. However, could be more interesting to summarise some considerations of general reach:

- In spite of the fact that in all the cases we try to introduce measures of correction, the volume of the problems is constantly increasing.
  Correction increases linearly, while problematic, crawled by quantitative and qualitative extension of artificial lighting, grows exponentially.
- Although in the last times informative diffusion related with this problematic has increased, it already exists an ignorance of this problematic.
- The introduction of corrective measures is slow and difficult.

It could imagine that this difficult is due to:

- Ignorance of the problem
- Underestimate of their repercussions
- Natural resistance to the change

Artificial lighting and human health

Light technicians are used to consider electromagnetic radiation only in its optic aspects, as a transmitter to the brain of information coming from external world.

However, the action of this radiation on the organism is bigger and it includes other access ways apart from optic nerve. Light affects all “human cover”, skin and hair, and also inside the eye it generates impulses that, instead of going to the visual cortex, they activate hypotalam and they regulate the development of a lot of physiologic processes in our organism.

In the ancestral evolution of our species this action has only been subjected to the action of solar light, which has a spectral composition and variable intensity, always inside of a limit and specified rhythms. The intensive use of Artificial Lighting in our society is nearly modifying sensitively this conditions, therefore, apart from exceptional affections –like erythema’s risk for UV radiation excess- it begin to denote risks of social health that mainly affect phenomenon related with our biological rhythm:

- Depression
- Stress
- Heart rhythm
- Dream rhythm
- Alert grade

denoting in some cases a correlation between work at night –and its corresponding alteration of light cycle- and the incidence of certain types of cancer.

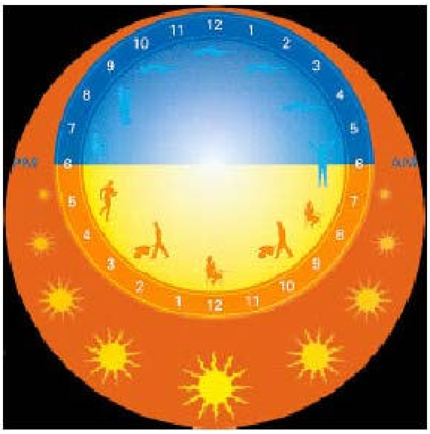

Figure 24

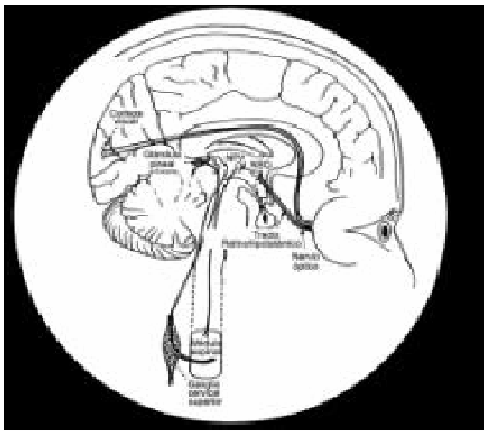

Figure 25

Although the investigation on these topics is very recent and it should even look deeply into a lot of fields, the evidence of relation between health and artificial lighting is already undeniable, and it forces to reformulate positions related with Artificial Lighting using, especially in the labour field.

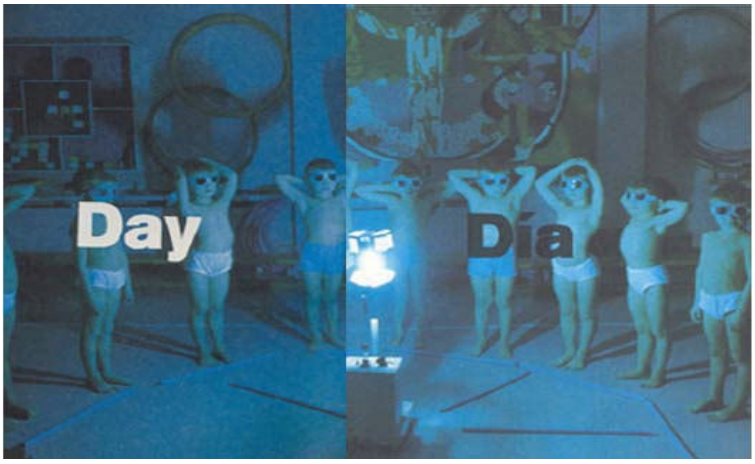

Figure 26

It also must to be pointed out that this relation does not only behave negative aspects, but also is opening the way to therapeutic application of light and to the development of biologic lighting systems that take advantage of the positive aspects of its incidence on the human being.

Globalisation: Artificial Lighting and equality

Edison was a great technical applications promoter, more than an inventor, among which undoubtedly there is the “electric bulb” , but he was not a good prophet when he affirmed that:
“the electricity will be so cheap that only the rich ones will light with candles”.

At the moment, one hundred twenty years passed from the appearance of his lamp, proximally two thousand millions of people –30% of humanity- does not have electricity and it has to continue using combustion as lighting source. It is not, certainly, part of the humanity economically well being, but it is the most prolific: its birth rate overcomes electrification one, for what this percentage is continually increasing.

Figure 27

Social benefits of Artificial Lighting mentioned are inaccessible for this important volume of human population. They are inside a situation that involve two hundred years behind schedule besides developed society. They use expensive, inefficient, weak and polluting lighting systems, and it is considered that “lighting consumption” (lumen-hour) per inhabitant is near a thousandth compared with other societies consumption.

Nowadays, in globalisation perspectives, it does not seems suitable to bet on the persistence of this situation. But repetition in this field of our habitual outlines could lead an increase maybe unsustainable of the analysed problems, so that it would be recommended to make more imaginative outlines.

CONCLUSIONS

Artificial Lighting contribution to the activity and well-being of our society is undeniable, and it is also an achievement that it should not be given up. On the contrary, the effort should continue and extend.
However, it is necessary to recognise that in the way to do it, it has been overcome, without advisement but excessively, certain limits. If, as it has been suggested before, XXI century wants to be qualified as a maturity period, it is necessary elaboration of new positions which clarify initial premises with the consideration more completed of analysed factors, and also opened to incorporate new possible aspects.

Artificial Lighting development has leaned on the technical evolution of systems, but also on social demand that, leaving from a limited objective to satisfy certain services (visual performance), and crossing comfort phase (visual comfort), it has reached some goals of satisfaction (visual amenity). But this evolution has also supposed that, while physiological factors have conserved an importance practically constant on demand composition, the influence of the cultural factors has been developed until being dominant.

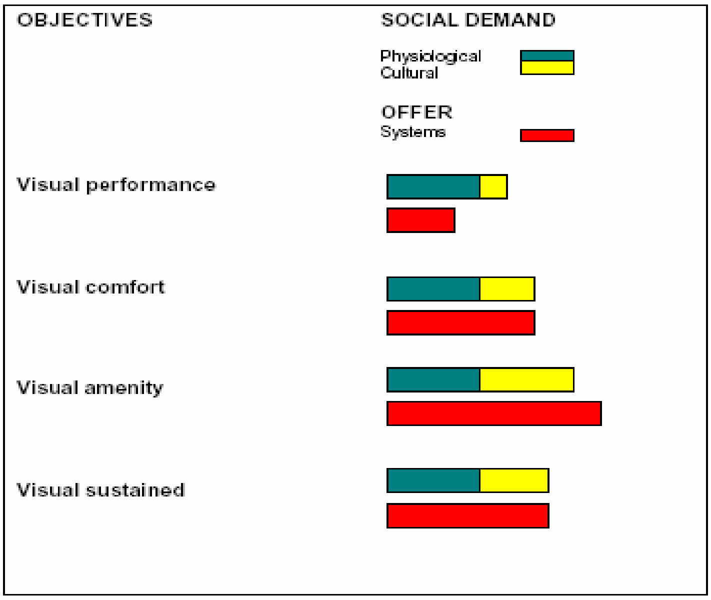

Diagram 5

Therefore, new phase approach, for which is proposed denomination of sustainability (visual sustained), involves technical measures and procedure one's, but mainly, a true cultural transition. In the current cultural paradigm brightness is success and penumbra is sadness, consumption is status and saving is poverty. In a recent meeting with a politician from our country, and talking about a geographical area so reduced of light pollution, his observation was: "Do you know what that means? That there is not life". To suggest that lighting levels have to be the necessary ones and not to overcome them without reason, that lighting has to stay in its field without invading spaces which do not need it, contradicts the values scale of our current light culture.

The sustainable approach suggested does not presuppose to give up the enjoyment of Artificial Lighting benefits, but supplementing with the consideration of its consequences and risks. To join to our legitimated aspirations of auto affirmation the recognition of its limits, an attitude of respect to environment and responsible consumption. To learn again that is light quality -and not quantity- what allows us see, and penumbra can be so gratifying and beautiful as light.

The data exposed in this article indicate that, although perhaps it does not coincide wit their conclusions, light professionals, in the XXI Century, should not continue thinking about our work in the same way. As we were able to suggest new ambitions to our objectives, now we have to be in order to admit new limitations. What benefits can they come from damage the environment and health, or to favour tensions between societies? Let us think it as a new challenge that we are going to know how it can be overcame, just as our recent history shows.

Josep Pla, the Catalan writer, in front of lightened windows in the sky-scrappers of Manhattan, said: " Very beautiful. But who pays for this light ?" It is a good question: who pays for this light?, and what is more important: how does he pay for it?

CENTENNARY OF SOLID STATE ELECTROLUMINESCENCE

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1 INTRODUCTION

During the present boom of solid state lighting few people are aware of the fact that the first description of solid state electroluminescence dates back to 1907[1], when Round fund that when a carborundum (SiC) crystal is contacted with a needle, a faint – mostly blue glow can be observed in the vicinity of the point contact. Some fifteen years later Lossew investigated the phenomenon in more detail[2,3,4]. Using present day terminology one would call the effect injection electroluminescence at a metal-semiconductor junction. The efficiency of light generation was however so low that no direct practical application was envisaged.

Some further 12 years later Destriaux described electroluminescence on thin films prepared by embedding ZnS powder in a dielectric matrix and placing this in a high alternating current field[5]. This type of solid state electroluminescence got practical application, although it did not attain the efficiency and widespread practical application that was hoped. It is still used in the form of some electroluminescent displays.

The big breakthrough was achieved when injection got systematically investigated in III-V compounds, i.e. for visible light first in GaAsP[6]. The knowledge obtained by the investigation, and practical use of semiconducting materials enabled physicists to build semiconducting p-n junctions, where the bandgap of the material corresponded to electron-energies of visible radiation, and thus when the injected current carriers recombined light was produced.

From the 1960's on questions of direct and indirect recombination (with their different emission probabilities) got understood, together with other phenomena of non-radiative recombination and the production and doping of higher bandwidth materials. This had as consequence a continuous increase in efficiency and the production of light emitting diodes (LEDs) of shorter and shorter emission wavelength. First red, then amber and finally green light emitting diodes came onto the marked and slowly became the prime sources for signalling applications in house-hold appliances and electronic instruments. They became also used in small, mainly seven segments displays. This application became the first challenge for photometry and colorimetry, as the visual brightness of these red and green displays differed from the measured luminances[7]. Unfortunately little attention was given by the CIE in those days to these findings.

Real attention to LEDs as light sources was obtained only when Nakamura succeeded to close the gap of the hue circle by producing also blue emitting LEDs (see e.g.[8]). This opened up the way for many further applications: using red, green and blue LEDs one could produce any shade of light (within the gamut area of the three basic colours), including white light, thus the application became interesting both for full colour displays and eventually general illumination.

The past ten years of technological progress increased the efficacy of both the coloured LEDs and of a special sort of white light producing LED family, the LED using a blue light emitting chip and a yellow phosphor converting part of this light into longer wavelength radiation, so that the mixture of the blue plus yellow light produced the sensation of white light.

At present one experiences a very rapid increase of the efficacy and of the luminous flux per LED unit, so that the LED light sources become a challenge for more and more applications. While a few years ago one could state that the coloured LEDs are an alternative light source in signalling applications, as they can produce coloured light with higher efficiency as any other general purpose white light source with an external colour filter, and thus became the main light source in traffic signals, but the white LEDs had to find niche applications where they could compete with traditional sources, as e.g. in refrigerated surroundings (as their efficiency rises with temperature decrease, just opposite to that of e.g. fluorescent lamps) or in applications where their high rigidity was of advantage.

White light LEDs compete now a day in efficacy with fluorescent lamps, coloured LEDs become the main sources for large area displays, and the colour changing possibilities of red-green-blue LED combinations make them much desired in artistic applications.

For all above applications the photometric and colorimetric characteristics of these sources have to be measured. CIE was able not to change the fundamental photometric system since 1924, and also its colorimetric system got only slight amendments during the past 76 years. It looks, however, that while it was possible to use the same photometric and colorimetric system while the change came from incandescent lamps to fluorescent and high-pressure gas discharge lamps, some more fundamental considerations will be necessary to cope also with LED lighting. In the following paper some of the questions, where according to the view of the present author new thinking is necessary, should be enumerated.

CHALLENGES FOR CIE PRODUCED BY LEDS

1.1 Photometric and colorimetric fundamentals

Photometry is built on the $V(\lambda)$ function. As early as 1951 Judd proposed a modification[9] of this function, which was not accepted, as the general opinion of the applied experts was that – for white lights – the difference is too small to be of any practical importance. CIE published the modified $V(\lambda)$ function in xxx as the $V_M(\lambda)$ function[10], but the Meter Convention has still not included it as a photometric actinic function into its system, thus no instrument can be calibrated legally to show photometric values based on the $V_M(\lambda)$ function, despite the fact that it would better describe visual impression we get for the light of a blue emitting LED. The differences are not negligible, as show in Table 1 on the example of a red, a green and a blue LED. The table shows also the effect if using a phosphor coated blue LEDs to produce white light.

Table 1 Luminous flux calculated on the basis if the $V(\lambda)$ and $V_M(\lambda)$ functions

LED light source	Lum. flux calculated using $V(\lambda)$ function	Lum. flux calculated using $V_M(\lambda)$ function
Red LED	12,7	12,7
Green LED	62,5	62,5
Blue LED	6,71	6,79
White p-LED[1]	99,8	100,21

Due to the fact that the brightness of coloured lights does not correlate with luminance (also not if the $V_M(\lambda)$ would be used), and the blue LED will not be used for task illumination, where luminance might be a good measure, this in itself is still not a convincing argument to change the photometric system.

If, however, also the colorimetric characteristics are considered, the situation looks quite different: If one matches e.g. the white light produced by an RGB-LED[1] with that of an incandescent lamp visually and measures the tristimulus values of both lights, one gets considerably different values[11]. Table 2 shows the measured chromaticity co-ordinates of the two lights matched in colour. In this case the calculated CIELAB colour difference – for adaptation to the incandescent lamp light – is $\Delta E_{ab}^* = 10{,}8$.

Table 2 Chromaticity co-ordinates of the light of an RGB-LED and of an incandescent lamp that match in colour visually, and CIELAB colour difference, assuming adaptation to the light of the incandescent lamp

Lamp type	x	y
Incandescent	0,4513	0,4100
RGB-LED	0,4431	0,3991

CIE TC 1-36 developed L, M, S cone fundamentals[12] that correlate better with the average human eye spectral sensitivities, based on these fundamentals Wold calculated colour matching functions[13] (CMFs), and we tested these not only by using the single white colour match, but also for a number of coloured lights and got the result that the CMFs based on the cone fundamentals provide much better agreement with visual matches then the CIE 1931 CMFs[14].

Figure 1 shows the chromaticities of visually matching lights of an RGB-LED cluster and an incandescent light, both using the CIE 1931 CMFs (Figure 1.a) and those based on cone fundamentals (Figure 1.b). The red diamond shows the measured chromaticity of the reference incandescent lamp, the yellow points are averages of matches performed by our nine observers, their

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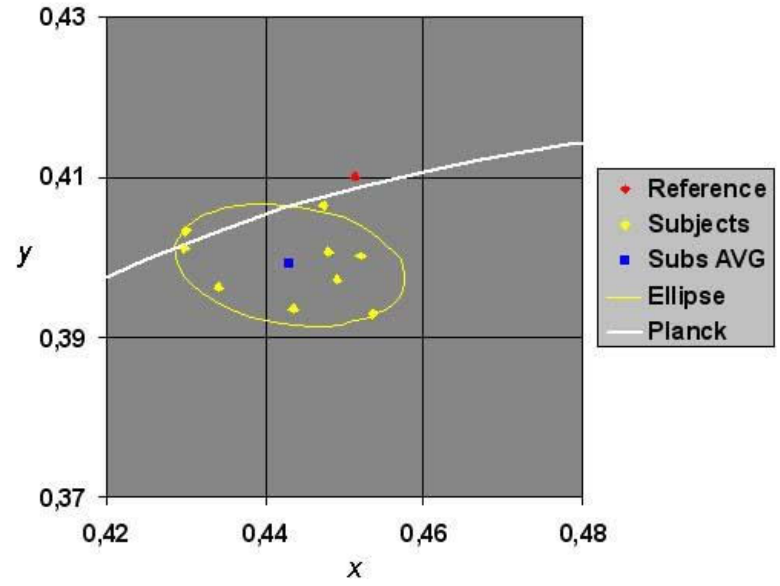
[1] In the following a white light emitting LED configuration if it is produced from three chips emitting in the red, green and blue part of the spectrum, respectively, will be called GRB-LED, and if it is produced from a blue chip plus a yellow phosphor it will be called p-LED.

average is shown by the blue rectangle. The yellow ellipse has been drawn to show average scatter of the many settings of the observers[2].

Results of a second experiment are shown in Figure 2. Here the incandescent lamp was filtered by a number of colour filters, and visual match was obtained by adjusting the currents of the LEDs. Again Figure 2 a. shows the measured chromaticities, now in the *u'*,*v'* co-ordinate system, using the CIE 1931 CMFs and Figure 2 b. shows them for the cone fundamental based system.

As can be seen from the figure the matches become quite good in the white, yellow, red part of the diagram, in the blue part they are sill not hundred per cent good, but the difference between the visual match and the instrumental becomes much smaller by using the new proposed CMFs. Further work is needed in this field, but definitely CIE has to address this question not only from the theoretical point of view of the cone fundamentals, but also for suggesting an (alternative, supplementary?) colorimetric system that can be used also for LED lighting.

a.)



b.)

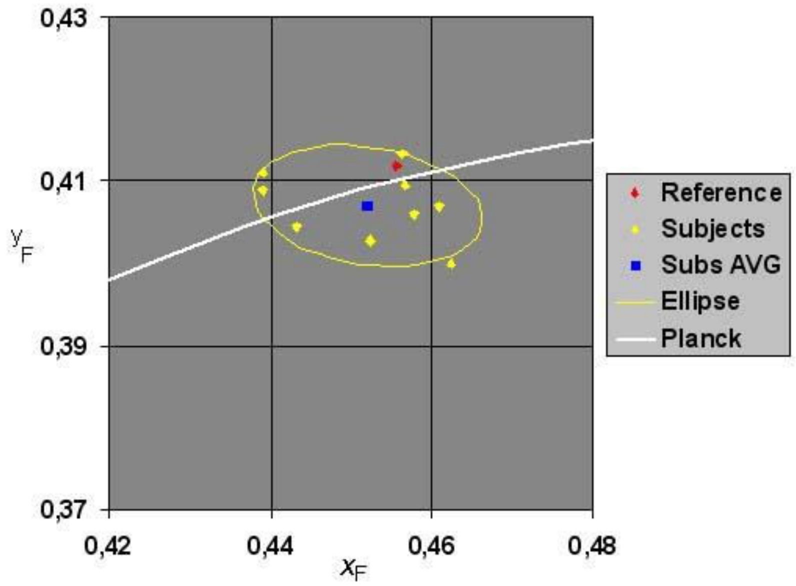


Figure 1 Chromaticities of colour matches between an incandescent lamp and an RGB-LED cluster, **a.)** using the CIE 1931 CMFs, **b.)** using the CMFs based on cone fundamentals.

[2] A detailed statistical analysis of these and further measurements will be given in a subsequent paper.

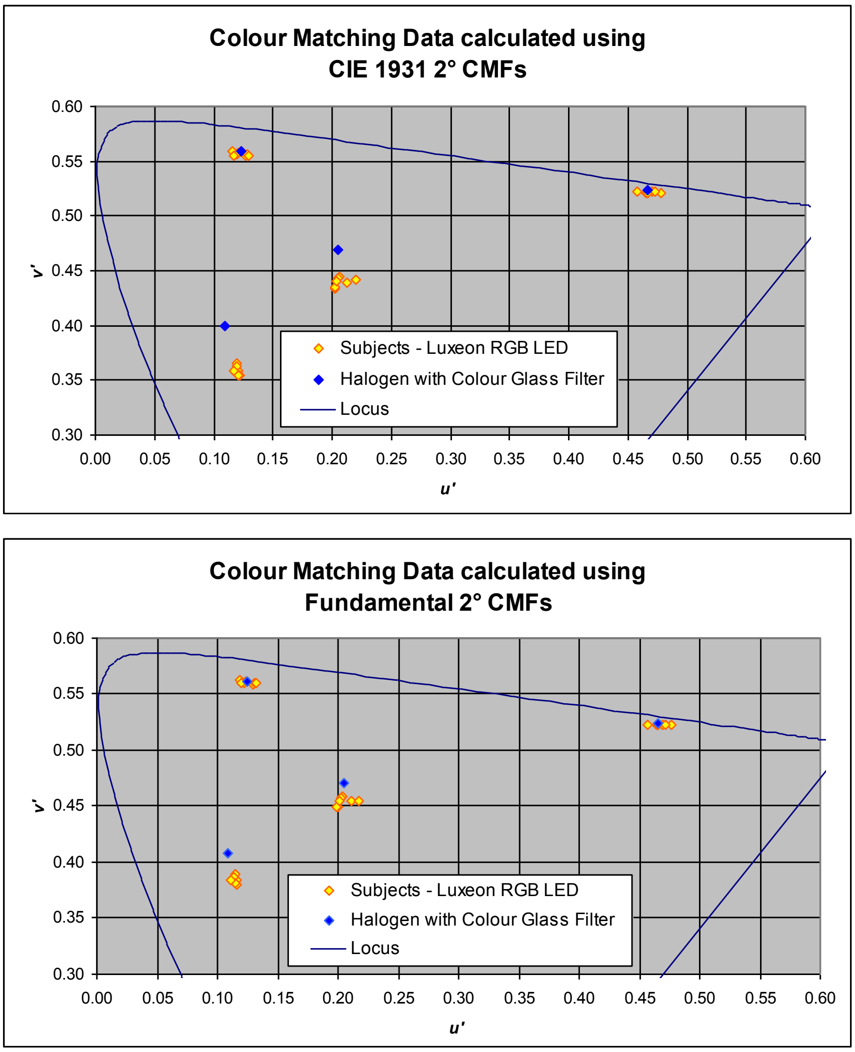


Figure 2 Measured chromaticities of a number of colour matches obtained between visual matches obtained between an RGB-LED cluster and filtered incandescent light. Figure *a* shows chromaticities for the CIE 1931 CMFs and Figure b for those based on the cone fundamentals.

1.2 Practical photometry and colorimetry

Both in photometry and colorimetry one is also faced with the problem, what uncertainty one has to expect by using commercial instruments to measure LED lights. While national laboratories agree already to a few per cent in their measurement results when measuring LEDs, the applied engineer is still let in darkness if practical measurements are to be taken, e.g. coloured LED traffic lights have to be evaluated. There are several recommendations how the spectral mismatch of a photometer should be described in case of LED measurements[15,16,17], but non of these got CIE acceptance yet.

The new draft edition of CIE Publication 127[18] introduced a number of new definitions, helping LED users to get more reliable results – and more importantly – results that can be compared in different laboratories. These are restricted, however, to geometric descriptions (partial flux measurement), and do not deal with the very important question of real application: under what electrical and thermal conditions have the LEDs to be measured. One could argue that these items are outside of the scope of the CIE, but without defining them no meaningful comparisons of the performance of the LEDs can be made. LEDs are highly temperature sensitive devices. With present high intensity LEDs the semiconductor materials are stressed to their limits. Manufacturers like to refer to junction temperature, but the user has access only to the base plate temperature of the LED. Some standardization is urgently needed as users are presently unable to evaluate the available LEDs according to their need. Just think about a big LED billboard, that has to produce a large enough contrast under direct sunlight, at outside temperatures of 35 °C. How can one select the appropriate LED if the temperature dependence luminous flux (or intensity) of the LED, and the relationship between the outside temperature and the chip temperature under the given, pulsed condition is not known?

In traditional luminaires only one or a few sources are mounted. In case of LED luminaires we have still a very high number of individual sources. Educators have to preach to the installation managers not to mix fluorescent lamps of different colours in one installation, because this produces undesirable visual impressions. With LEDs the problem is much larger: manufacturers have to bin their products into chromatic and efficacy classes. But what should be the size of the colour bin? How large colour difference do we perceive if say 50 or 100 LEDs are in a luminaire? For white light applications one will not try to look into the luminaire, for coloured ones – however – if it is a signal lamp, one looks directly onto the panel with the LEDs of slightly different colour. What is the physiologically permissible difference among the single LEDs? Questions that CIE vision research should answer, but where a wrong decision might be connected with large costs. CIE should probably make it clear to the manufacturers that the support of research in this area was not needed in the pre-LED area of lighting, thus no answers are ready, but it is in their interest to support research in such fields.

1.3 Colour rendering and LEDs

With the availability of white LEDs a new investigation of the CIE test method for colour rendering[19] started. Since the introduction of the CIELUV and CIELAB colour spaces several attempts were made to modernize the CIE test sample method, without a major success[20] (for a summary description of colour rendering and similar subjects see[21]).

CIE TC 1-69[22], responsible to develop a new descriptor for the colour quality of light sources, is of the opinion that a new index should not replace from one day to another the present colour rendering index, but should complement it, and hopefully replace it, when it becomes clear that it gives a better descriptor of the colour quality of the light the lamp emits than the CIE test method. In the following some thoughts that might help to understand the requirements one might have when a new metric is developed should be presented. These are based partly on literature data, and partly on the experiments conducted in the laboratory of the author and do not reflect any CIE endorsed thinking.

The wish to supplement colour rendering with further quality descriptors is not new. Judd coined the term flattery index already in 1967[23]. The flattery index was intended to describe whether a light source renders colours in a more pleasant (flattery) way than an other source. Jerome discussed the differences between flattery and rendition in detail[24]. Later the word *preference* was used instead of flattery[25]. Thornton's calculation showed that colour rendering and colour preference indices do not have their optimum value at the same spectral distribution[27]. Some experiments tried to combine the colour preference and colour rendition aspect in such a way that the maximum of colour rendition remained if the test source had the same SPD as the reference illuminant, but the worsening of the index was slower if the colour difference between the sample illuminated by the test source compared to the illumination by the reference illuminant deviated in the direction of higher chroma, or e.g. in case of complexion towards redder hues[26]. Other ideas went into the direction to develop a colour discrimination index, eventually based o gamut area spanned by the test samples in a uniform chromaticity scale diagram, as there are a number of tasks where the discrimination between small colour differences is important[27,28]. All these can be supported by simulation experiments[29]. Also Davis and Ohno published on improved colour quality metrics[30].

The comfort experience in an interior setting is also influenced by the colour quality of the lighting. Bellchambers investigated visual clarity[31] and found correlation between visual clarity, illumination and colour rendering. Other investigations tried to correlate the different aspects of lighting quality as well (see e.g.[32]).

An interesting new approach is based on the hue shifts of a high number of colours. This wouold show which hues are highly distorted compared to a reference and which are rendered correctly[33,34].

1.3.1 Colour quality simulation

Our recent studies go in a similar direction by starting from the supposition that if a designer has carefully chosen the colours of an environment to be pleasant under one light source, i.e. the observer gets a harmonious impression of the environment, then an other light source will be accepted if after chromatic adaptation transformation the colours of the environment stay harmonious[35]. A further papers deal with this subject at this meeting[36]. We based our experiments on McCann's observation that when the shift of each colour in a set goes in a systematic order (e.g. all hues shift in the same direction, or all colours get lighter or darker, or all chroma increase or decrease) the result is more acceptable compared to a colour distortion when the colours move in different directions in colour space.

A second approach was based on visual evaluation on the similarity versus dissimilarity of an image when illuminated with one light source or an other[37]. The development of a reasonable colour appearance model[38] enables the display of scenes transformed to that under a reference illuminant on a visual display unit. We have performed such simulated scene comparisons, requesting observers to compare a scene as it would look under a reference illuminant (CIE D65) and under a test illuminant. With this approach one can test whether it is appropriate to use one single reference illuminant (as supposed by several critics of the present colour rendering test method), or it is more appropriate to define a number of reference illuminants depending on the task for which the lighting is used.

Pilot experiments have shown[37] that if one supposes one perfect reference illuminant (D65) then there will be a number of sources, with different correlated colour temperatures, that will rank higher than CIE standard illuminant A, which – according to the CIE test method – ranks equally high than D65. Experiments are under way with different scene arrangements (living room, office, etc.) to see whether the average observer will select as optimum CCT a different value for one ambience than for an other.

CONCLUSIONS

The introduction of LEDs into different lighting applications produce a number challenges for CIE. A better description of the fundamental visual functions seems to be necessary to avoid erroneous chromaticity assessments. This could have an influence also on the luminance evaluation - not speaking of the proper description of the brightness of colourer lights.

Colour rendering – or better said – the colour quality description of light sources, LEDs included is a hot topic. We think that our simulation experiment are a good method for such investigations. They showed clearly that the method of showing the images of one scene as it would look under different illuminants – but after chromatic adaptation – is a valid method to investigate lamp-light colour quality.

In this respect visual there are experiments under way both in our laboratory and in a number of other laboratories, so that one can hope to get some important results in the near future.

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LUMINOUS ENVIRONMENT OF DIFFERENT STREETSCAPE IN SEOUL

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ABSTRACT

The nightscape of Seoul has been drastically improved in the last 15 years. Rapid change of lifestyle during night has activated the urban illumination and renovated interest of street lighting environment has increased in the last 10 years in Korea. This paper aims to analyze the luminous environment of two different of street. Traditional Street (Insa-dong) and modern street (Myung-dong) were chosen for the study as Seoul has mixed culture with traditional and the modern streets. . For the analysis of the lighting environment horizontal illuminance and luminance of building surfaces, signboard, pedestrian, shop window and sky are measured.

Keywords: Streetscape, Street lighting, Outdoor Lighting, Horizontal illuminance, luminance

1 INTRODUCTION

Seoul is the metropolitan city with the traditional cultural heritage and the modern buildings. In addition, as the new way of life appears, a renovated interest of street lighting environment has increased in the last 10 years in Korea.

The street is mainly used by pedestrians and influenced by the buildings and trees in daytime. At night this urban space receives a new appearance due to applied lighting equipments. The perception of night streetscape is basically defined by the outdoor and indoor lighting of the building, particularly with the street light, light installation and the shop window. In street light, the beautification should be considered as well as the convenience, safety, and security of pedestrians. Consequently, the image of the lit street is very important not only for the local users but also for the foreign tourists. Therefore coordination between street light, signboard and shop window lighting are needed for the better night environment in street.

In this study, lighting environment in different night streetscape was analyzed and evaluated. The traditional commercial street and modern commercial street in Seoul are chosen. For the analysis of the lighting environment, luminance of building surfaces, signboard, pedestrian, shop window and sky , Horizontal illuminance are measured.

2 CHARACTERISTICS OF THE STREET

Insa-dong and Myung-dong were selected as the traditional commercial street and the modern commercial street, respectively, with the different lighting environment in Seoul. Insa-dong street has been recognized as the traditional cultural street harmonized with history and culture. For pedestrian use only and traditional culture in the street, a new arrangement has been accomplished by the government. There are antique shops, galleries, and antique book stores. Signboard and street lights are controlled by local regulations. Therefore Insa-dong has the monotony nighttime image beside the shop lights. Insa-dong has the street light installed for approximately of 10 m on the entry part, and 30 m thereafter. The width is 10-12 m and the length is 690 m. The street length for the study is approximately 400 m to the north-south direction.

Myung-dong has many kinds of offices and shopping buildings in the surrounding area. 3-5 floor buildings are in front, and high-rise building in the backside. Along the street there are many clothing stores, restaurants, and cosmetics stores, and this area is heavily used at night. Lighting environment of Myung-dong consists of street lighting, signboard, and show window of the buildings. The street lights are located approximately 50m interval. The street length selected for the study is approximately 400 m and the width of cross is approximately 10m from the Myung-dong Station direction.

Night and day photographs of Insa-dong and Myung-dong are in Table 1.

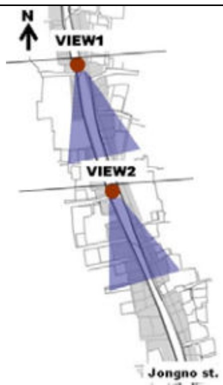
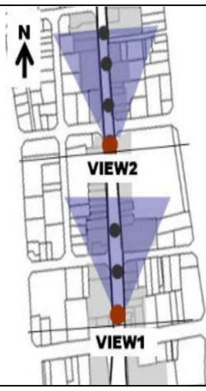
Table 1 Day & Night image of the Street

	Insa-dong		Myung-dong	
Day				
Night				

3 MEASUREMENT

The Measurement was conducted under same sky condition from 7pm to 10pm on March 12, 2007. Vertical illuminance and luminance of building's surface, signboards, street light, pedestrian, and sky were measured for each street. Prometric1400, digital camera, Topcon IM-5, PC were used for measurement. The measurement of the vertical illuminance was measured by dividing into seven points with the same length of 50m of the street. The streets are classified with view 1 and view 2 for each street for measurement. The measurement points were selected where the both side buildings could be seen in field of visual angle.

Table 2 Measurement Set up

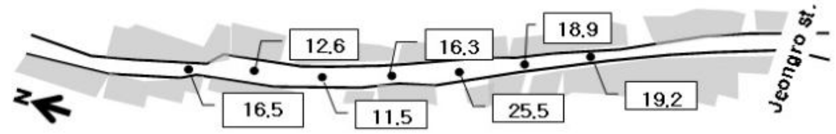
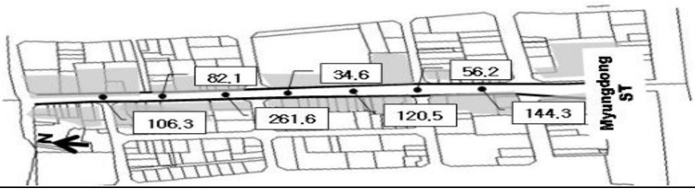
	Insadong	Myungdong
Direction	South - North	South - North
Length	400 [M]	400 [M]
Width	12 [M]	12 [M]
Measurement Point		

4 RESULTS

4.1 Horizontal illuminance

Measured illuminance in Insa-dong was 11.5 [lx] - 25.5 [lx]. The general trends of measured vertical illuminance were similar at 17.1 [lx]. This figure is the appropriate for the commercial area illuminance distribution, due to the fact that in Korea standards [KS, A3701]] the recommended commercial area illuminance is 20 [lx] In Myung-dong, area with less outdoor lightings and advertising billboard were measured at 34.6-82.1 [lx]. But where the various signboard and street lightings were located, the measured illuminance values were from 128.5 [lx] -261.6 [lx]. Namely, Myung-dong displayed 7 times of illuminance deviation. In addition, it is shown to be higher than the recommended illuminance level in KSA3701. The illuminance results are shown in table 3.

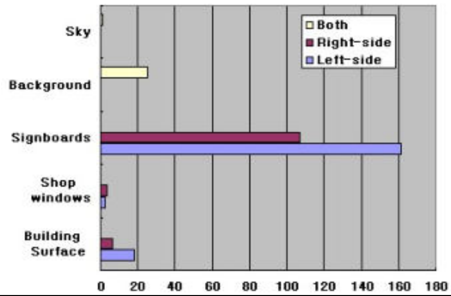
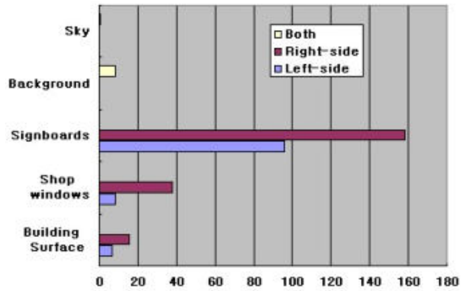
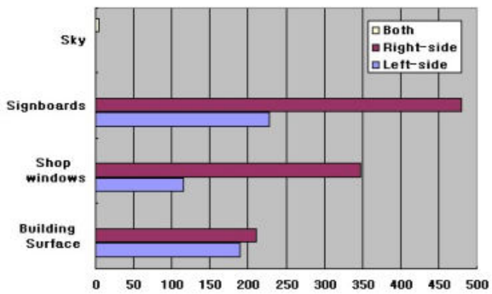
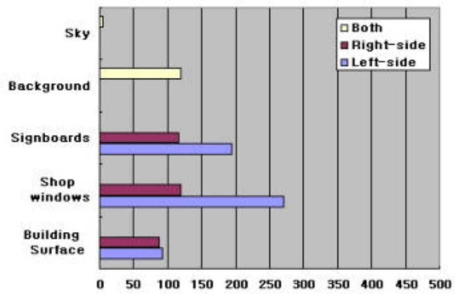
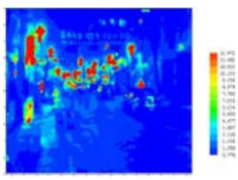
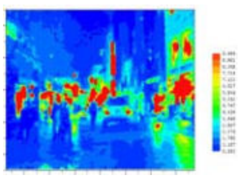
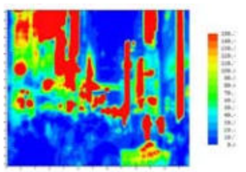
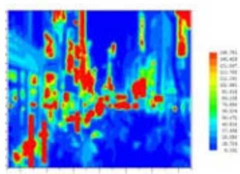
Table 3 Illuminance Distribution in streets

<table>
<tr><th></th><th>Illuminance Distribution</th></tr>
<tr><td>Insa-dong</td><td>
</td></tr>
<tr><td>Myung-dong</td><td>
</td></tr>
</table>

4.2 Luminance

Insa-dong is mainly lighted with street light. In pedestrian luminance, similar luminance values are obtained with 1.0-2.2 [cd/㎡]. In View 1, the surface luminance of left-side buildings were 2.6 [cd/㎡] – 5.5 [cd/㎡] and the right-side buildings were 3.6 [cd/㎡] - 5.0 [cd/㎡] respectively.

Table 4 Luminance Distribution

<table>
<tr><th></th><th colspan="2">Insa-dong</th><th colspan="2">Myung-dong</th></tr>
<tr><td>View 1</td><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td>View 2</td><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td rowspan="2">Image</td><td>View 1</td><td>View 2</td><td>View 1</td><td>View 2</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Luminance distribution</td><td></td><td></td><td></td><td></td></tr>
</table>

For show window luminance, view1 showed 2.6 [cd/㎡] - 3.6 [cd/㎡] while view2 shows 8.4 [cd/㎡] -38.0 [cd/㎡]. The building surface luminance were 6.3 [cd/㎡] -17.9 [cd/㎡], which is 1.3-3.9 times lower than CIE recommendation of surface luminance of the buildings. The signboards luminance were also 4.4 - 10.4 times lower than the CIE recommendation (150:2003) with value of 96-227 [cd/㎡]. And the measured sky luminance were between 0.75 [cd/㎡] and 0.88 [cd/㎡].

Generally, the luminance value in Myungdong were higher than Insa-dong due to the various light source. The average luminance of both buildings under View 1 showed 190[cd/㎡] on the left side and 211[cd/㎡] on the right side. In View 2, 93[cd/㎡], 87[cd/㎡] were measured respectively. For show window of the buildings in view1 and view2 were in the range of 136[cd/㎡] - 347[cd/㎡]. Compare to the CIE Recommendation(150:2003), luminance of the building surfaces showed 4.8 times to 13 times higher than the recommended luminance. In addition, visual discomfort and light pollution may be inferred. The sky luminance of 4.9[cd/㎡] were measured.

5 CONCLUSION

Luminance and horizontal illuminance of night streetscape is mutually different as follows.

In Insa-dong horizontal illuminance of the street was very uniform. It could emphasize the unity of the street. According to KS and CIE recommendation, It showed adequate or relatively lower figures. Minimum use of lighting could represent the characteristics of Insa-dong. It is possible to control more exciting lighting environment within the KS and CIE recommendation in the future.

High illuminance and luminance were measured in Myungdong due to a various light environment compared to Insa-dong. In addition, the surface luminance of the signboard was adequate to the CIE recommendation. However, building surface with outdoor lighting and signboards had 13 times higher luminance distribution than the recommended surface luminance and could generate the light pollution for pedestrians. Myungdong requires a strict control of private lighting, especially advertisement lighting and light sources.

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STUDIUL INFLUENȚEI INSTALAȚIILOR CU ARC ELECTRIC ASUPRA SISTEMULUI DE ILUMINAT ARTISTIC

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ABSTRACT

In the present paper it was analyzed the electromagnetic compatibility between the installations with electric arc and lighting system connected to the same electric power network. It was taken a real network for power distribution at the voltage 6 kV at which are connected in parallel an electric arc furnace for metal melting installed at the S.A. "Aralit" and the artistic lighting system of the Opera and Ballet Theatre from Chişinău municipality.

1 INTODUCERE

Funcționarea normală a receptoarelor electrice (RE) în mediul electromagnetic dat (rețeaua electrică) este determinată de asigurarea compatibilității electromagnetice a acestor RE cu rețeaua electrică. Reieşind din specificul rețelei electrice, aceasta admite un nivel normat admisibil de compatibilitate, care nu trebuie să influențeze performanțele RE, adică ultimul trebuie să dispună de o imunitate la eventualele perturbații conduse. Or, depăşirea nivelurilor admisibile stabilite vor înrăutăți caracteristicile tehnice şi economice ale receptoarelor electrice.

Calitatea energiei electrice (CEE) reprezintă o componentă foarte importantă a compatibilității electromagnetice, ce caracterizează mediul electromagnetic. Efectuarea studiilor şi încercărilor privind CEE în sistemele de alimentare cu energie electrică arată, că gradul de influență a RE şi echipamentului electric asupra CEE este semnificativă.

În prezenta lucrare se analizează compatibilitatea electromagnetică dintre cuptoarele cu arc electric (CAE) şi sistemul de iluminat artistic conectate la aceeaşi rețea electrică. Se studiază o rețea electrică de distribuție reală la tensiunea 6 kV, la care sunt conectate în paralel un cuptor cu arc electric pentru topirea metalelor din cadrul S.A. „Aralit" şi sistemul de iluminat artistic al Teatrului de Operă şi Balet din municipiul Chişinău (fig.1). La funcționarea cuptorului cu arc electric se produc perturbații de joasă frecvență sub formă de fluctuații de tensiune inadmisibile şi armonici superioare de tensiune şi de curent cu amplitudini şi frecvențe mari, care duc la deteriorarea rapidă a sistemului de comandă şi respectiv a lămpilor şi transformatoarelor lor din cadrul sistemului de iluminat artistic al teatrului. Nivelul admisibil al fluctuațiilor de tensiune poate fi evaluat după unul din indicatorii de calitate a energiei electrice, ce caracterizează fluctuațiile: amplitudinea de variație a tensiunii şi doza de flicker [1, 2].

2 CAUZELE ŞI EFECTELE FLUCTUAȚIILOR DE TENSIUNE

Cuptoarele cu arc electric, ca obiect de studiu, fac parte din categoria receptoarelor electrice care provoacă în timpul funcționării şocuri aleatorii de putere reactivă, necesară atât pentru asigurarea procesului de topire, cât şi pentru a compensa pierderile de putere reactivă în elementele instalației cuptorului [3,4]. Funcționarea cuptorului cu arc electric este însoțită de un şir de fenomene, care pot să influențeze negativ funcționarea altor consumatori, racordați în acelaşi punct cu cuptorul (fig.1). Afară de fluctuații de tensiune, în rețelele ce alimentează cuptoarele cu arc electric mai pot fi evidențiate perturbații [5], cum ar fi nesimetria tensiunilor de linie şi a curenților pe faze, nesinusoidalitatea curbei de tensiune, supratensiuni în elementele sistemului de alimentare cu energie electrică, ca rezultat al operațiilor de comutare în instalațiile cuptorului. Ca urmare aceste perturbații crează efecte negative ca:

– variația vizibilă a fluxului luminos emis de sursele de iluminat artificial, fenomen care produce, în domeniul de frecvență 1-25 Hz o senzație de jenă fiziologică a ochiului omenesc (efect de flicker),
– având ca rezultate: oboseala, scăderea productivității muncii şi mărirea probabilității de eroare în procesele de producție;
– deranjamente în funcționarea instalațiilor de automatizare şi comunicații;

– înrăutăţirea funcţionării instalaţiilor şi aparatelor electronice.

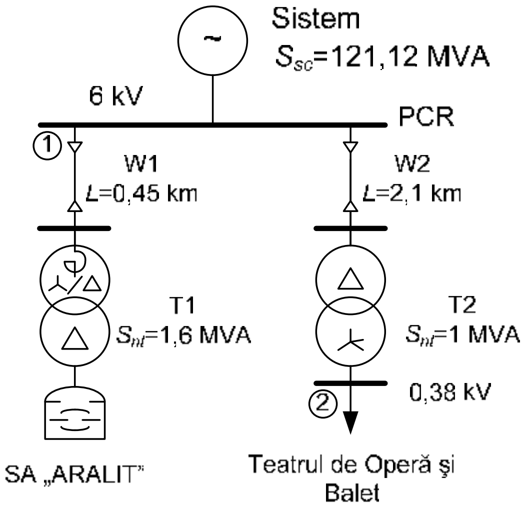

Figura 1 Schema de racordare a cuptorului cu arc şi a sistemului de iluminat artistic al teatrului la reţeaua electrică de distribuţie

Cuptoarele cu arc electric reprezintă nişte receptoare electrice specifice cu o sarcină continuă ciclică, caracterizată prin succedarea topirilor, cu oprirea cuptorului pentru scurgerea metalului lichid, încărcarea şi surparea încărcăturii. În timpul funcţionării cuptoarele provoacă şocuri aleatorii de putere reactivă. Consumul de putere reactivă este determinată de necesitatea asigurării unui unghi destul de mare de defazaj între curent şi tensiunea în circuitul de alimentare a cuptorului. Aceasta asigură procesul de topire prin menţinerea arderii continue a arcului electric, precum şi compensarea pierderilor de putere reactivă în elementele instalaţiei cuptorului (transformatorul cuptorului, reţeaua scurtă).
Studiul privind funcţionarea CAE necesită, in primul rând, de a cunoaşte următorii factori:
1. Caracteristica CAE, adică destinaţia, tipul, materialul topit, capacitatea nominală, parametrii transformatorului cuptorului şi echipamentului electric (inclusiv impedanţa circuitului secundar şi primar), sistemul automat de reglare, procesul tehnologic, caracterul sarcinii şi consumul de putere activă şi reactivă;
2. Caracteristica alimentării cu energie electrică a cuptorului, inclusiv schema reţelei interne (în cadrul întreprinderii) şi externe (reţeaua furnizorului de energie electrică), raportul puterii nominale a transformatorului cuptorului către puterea de scurtcircuit (s.c.) a sistemului în punctul de conectare, prezenţa instalaţiilor de compensare;
3. Perturbaţiile create de CAE, tipul consumatorilor sensibili, evaluarea cantitativă a fluctuaţiilor de tensiune pe barele centrelor de alimentare (staţiile de transformare ale furnizorului) şi prezenţa lor în reţelele electrice de distribuţie.

În reţelele electrice ce alimentează cuptoarele cu arc electric pot fi evidenţiate următoarele tipuri de perturbaţii:
– abateri şi fluctuaţii de tensiune;
– nesimetria curenţilor pe faze şi a tensiunilor de linie;
– nesinusoidalitatea formei curbei de tensiune (armonici superioare ale tensiunii şi curenţilor pe partea de ÎT a transformatorului cuptorului);
– supratensiuni în elementele sistemului de alimentare cu energie electrică, ca rezultat al operaţiilor de comutare în instalaţiile cuptorului.

Cele mai importante şi mai evidenţiate perturbaţii sunt fluctuaţiile de tensiune, care au influenţă negativă în special asupra iluminatului electric, precum şi deseori nemijlocit asupra cuptorului. Natura acestor fluctuaţii este determinată de fluctuaţia curenţilor arcurilor. Fluctuaţiile curenţilor sunt provocate de:
– surpările de material ce produc frecvente s.c. monofazate, bifazate sau trifazate, care alternează cu întreruperi totale, având drept consecinţă variaţii aleatoare ale curentului de ordinul (0...2)I_n;
– variaţiile continue ale lungimii arcului, care se amorsează pe diferire vârfuri ale încărcăturii; dispariţia prin topire a acestor puncte de sprijin ale arcului, la intervalele de 0,1...0,4 s, conduce la o continuă deplasare a lungimii arcului; fluctuaţiile curentului constituie (0,4...0,5) I_n;
– întreruperile programate ale sarcinii, fie pentru completarea încărcăturii, fie pentru modificarea tensiunii arcului, care se realizează prin ridicarea electrozilor; drept rezultat curentul scade la zero în

1-2 s, iar coborârea electrozilor în cuvă duce la o creştere bruscă a curentului.

Cele mai mari şi mai frecvente fluctuaţii ale curenţilor au loc în perioada topirii şarjei solide, astfel că pe diferite faze ele apar nesimultan, ceea ce provoacă nesimetria curenţilor şi indică preponderenţa salturilor monofazate ale curentului. Drept dovadă serveşte rezultatele măsurătorilor efectuate pe barele de alimentare ale transformatorului cuptorului, unde numărul de fluctuaţii inadmisibile ale tensiunii pe faze diferă (A – 111, B – 55, C – 129), precum diferă şi valoarea amplitudinii de variaţie a tensiunii (de la 1,47% până la 7,62%) şi intervalul între aceste variaţii (de la 0,06s până la 83,33s). Micşorarea fluctuaţiilor are loc la formarea vanei lichide astfel, că în cazul funcţionării cu arc scurt la un factor de putere mic, valoarea fluctuaţiilor de tensiune este mai mică comparativ cu funcţionarea cu un arc lung şi la un factor de putere mai mare. La etapa formării topiturii, fluctuaţii inadmisibile nu se înregistrează.

Totodată, fluctuaţiile tensiunii în reţeaua de alimentare sunt cu atât mai mari cu cât e mai mare puterea transformatorului cuptorului şi mai mică puterea de s.c. a sistemului în punctul de conectare a cuptorului. Raportul acestora în punctul comun de racord al CAE şi altor consumatori nu trebuie să depăşească 1%:

$$\delta U_t^{\%} = \frac{S_{nt}}{S_{sc}} 100\,\% \le 1\% \,. \tag{1}$$

Însă, în cazul dat trebuie de ţinut cont şi echipamentul electric ce intră în circuitul de alimentare al cuptorului, în special de parametrii reactorului, care în cazul examinat, este încorporat în transformatorul cuptorului.

3 EVALUAREA FLUCTUAŢIILOR DE TENSIUNE

Conform [5], fluctuaţiile admisibile de tensiune în reţelele electrice, ce alimentează în comun cu cuptoare electrice şi alţi consumatori, în caz general, nu trebuie să depăşească 1 %. Aceasta înseamnă, că dacă în PCR raportul puterii transformatorului cuptorului către puterea de s.c. nu depăşeşte limitele de 1%, atunci cu mare probabilitate se poate de aşteptat ca fluctuaţiile de tensiune nu vor depăşi limitele admisibile. Astfel, reieşind din condiţiile analizate (Figura1), valoarea amplitudinii de variaţie a tensiunii în PCR conform relaţiei (1) constituie:

$$\delta U_t = \frac{1{,}6}{121{,}12} \cdot 100 = 1{,}32 > 1\% \,.$$

După cum se observă, valoarea amplitudinii de variaţie a tensiunii depăşeşte valoarea admisibilă de 1 %. Aceasta demonstrează că, fluctuaţiile puterii reactive ale cuptorului determină apariţia fluctuaţiilor inadmisibile ale tensiunii, intensificând efectul negativ asupra reţelei electrice de distribuţie 6 şi 0,4 kV.

În scopul verificări veridicităţii acestor rezultate, în punctul de conectare al cuptorului şi al consumatorului sensibil (80 % din sarcină este iluminatul electric artistic comandat al Teatrului de Operă şi Balet) au fost efectuate măsurători ai amplitudinii de variaţie a tensiunii (Figura 1, în pp.1,2) cu ajutorul analizorului de CEE tip ERIS-KE.02. Acest aparat este prevăzut pentru măsurarea şi înregistrarea tuturor indicatorilor de CEE stabiliţi de [2] şi este destinat pentru controlul şi analiza CEE în reţelele electrice mono- şi trifazate cu frecvenţa nominală 50 Hz.

Conform [2], valorile limită admisibile ale amplitudinilor de variaţie a tensiunii pentru fluctuaţii de tensiune de formă meandru se stabilesc în dependenţă de frecvenţa de repetare a variaţiilor tensiunii pe minut ($F_{\delta Ut}$) sau de intervalul între variaţiile de tensiune ($\Delta t_{i,i+1}$) după Figura 2.
Amplitudinea de variaţie a tensiunii δU_t (în procente) se determină cu relaţia:

$$\delta U_t = \frac{|U_i - U_{i+1}|}{U_{nom}} \cdot 100 \,, \tag{2}$$

unde U_i, U_{i+1} sunt valorile extremelor ce urmează una după alta sau a extremei şi sectorului orizontal a curbei valorilor medii pătratice a tensiunii de frecvenţa fundamentală, determinate la fiecare semiperioadă a frecvenţei fundamentale.

Calitatea energiei electrice în PCR în cazul oscilaţiilor periodice ale tensiunii, se consideră corespunzătoare cerinţelor stabilite de [2], dacă valoarea măsurată a amplitudinii de variaţie a tensiunii nu depăşeşte valorile, determinate după curba din fig.2, în corespundere cu frecvenţa de repetare a variaţiilor tensiunii pe minut sau de intervalul între variaţiile de tensiune.

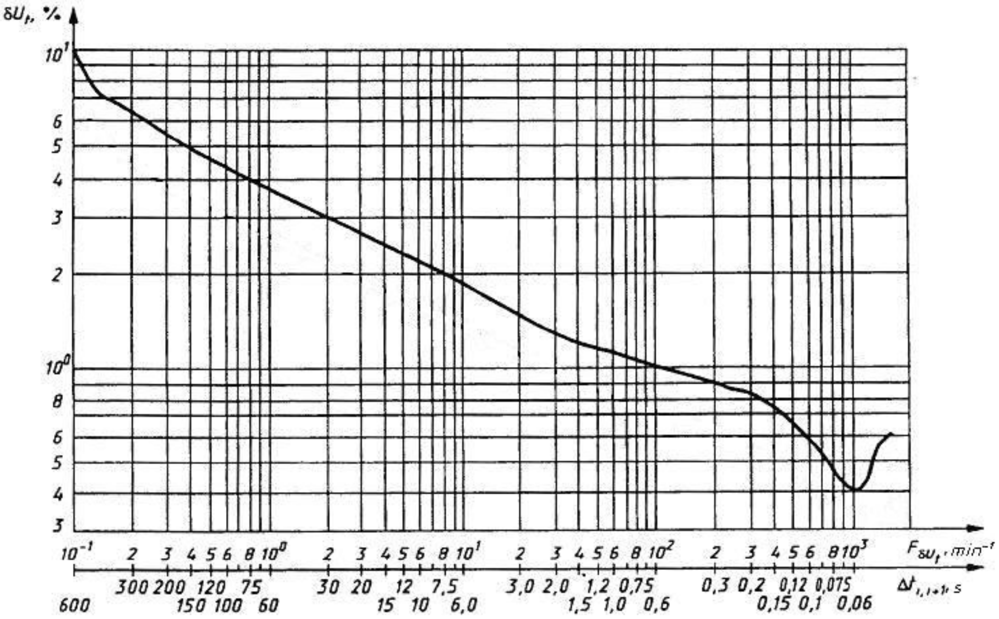

Figura 2 Valorile limită admisibile ale amplitudinilor de variație a tensiunii

4 ANALIZA ŞI COMPORTAREA SISTEMULUI DE ILUMINAT ARTISTIC LA PERTURBAȚII

Sistemul de iluminat artistic al Teatrului de Operă şi Balet (fig.3) are o putere instalată totală de 1 MW, fiind format din 4 transformatoare T3 (380/260 V) cu puterea nominală de 250 kVA, sistemul de comandă SC (regulatoare cu două tiristoare cu puterea de 5 şi 10 kW) şi lămpi HL alimentate prin intermediul transformatoarelor T4. Sistemul de comandă asigură la ieşire valoarea de tensiune necesară în limitele 0...260 V. Tiristoarele, la curenți nominali 50 şi 160 A, asigură reglarea şi trecerea ambelor alternanțe ale tensiunii de intrare. Apariția fluctuațiilor inadmisibile de tensiune în rețeaua de alimentare provoacă închiderea unuia din tiristoare, ceea ce permite trecerea doar a unei alternanțe pe o perioadă şi respectiv apariția componentei tensiunii de curent continuu [8]. Această tensiune duce la supraîncălzirea transformatoarelor T4 şi reducerea duratei de funcționare a lor şi a lămpilor de iluminat artistic.

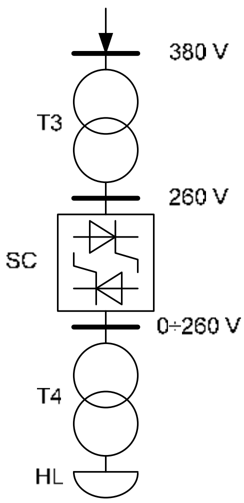

Figura 3 Schema de alimentare a sistemului de iluminat

Totodată apariția fluctuațiilor duce la crearea unui discomfort în asigurarea prezentării normale a spectacolelor şi a securității antiincendiare a teatrului.

5 SOLUȚII ŞI MĂSURI DE REDRESARE A SITUAȚIEI

Micşorarea fluctuațiilor de tensiune pe barele 6 kV a stației de transformare orăşeneşti reprezintă o problemă discutată şi de comisia specializată, sub conducerea ministerului de profil. Astfel măsurile eficiente şi economico-financiar posibile pentru micşorarea perturbațiilor, pentru cazul analizat, pot fi: folosirea pe deplin a metodei reactanței negative (transformatorului de putere din stație este cu înfăşurări secundare jumelate, care sunt unite în paralel formând un racord în loc de două), utilizarea avantajului funcționării compensatoarelor sincrone, alimentate de pe aceleaşi bare; utilizarea reactoarelor; utilizarea, în special la cuptorul cu arc electric, a instalațiilor de compensare a puterii reactive statice comandate; reconfigurarea rețelei electrice de distribuție de medie tensiune; eficientizarea procesului tehnologic, în special respectarea condițiilor normale de exploatare a cuptorului.

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EXTERIOR RAILWAY LIGHTING DESIGN ACCORDING TO prEN 12464-2 / CIE S 015

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ABSTRACT

The draft European Standard prEN 12464-2 "Lighting of work places – Part 2: Outdoor Work Places" specifies the lighting requirements for the lighting of tasks in most outdoor work places – including railways and tramways - and their associated areas in terms of quantity and quality. Furthermore the standard sets limits of obtrusive light for exterior lighting installations which are based on publication CIE 150:2003. Lighting levels are given in terms of average maintained illuminances of task and surrounding areas. For the calculation of illuminances and uniformities the maximum grid cell sizes can be evaluated using a formula which takes into account the actual dimensions of the area under consideration. The glare directly from the luminaires of an outdoor lighting installation is determined using the CIE Glare Rating (GR) method described in publication CIE 112:1994.

1 INTRODUCTION

The draft European Standard prEN 12464-2 "Lighting of work places – Part 2: Outdoor work places" [1] specifies the lighting requirements for the lighting of tasks in most outdoor work places and their associated areas in terms of quantity and quality. In a comprehensive table requirements are given for the exterior lighting of railways and tramways. Despite of different normative references this standard is identical with the CIE Standard S 015 "Lighting of Outdoor Work Places" [2].

These standards specify lighting requirements for outdoor work places which meet the needs for visual comfort and performance; they do not specify lighting requirements with respect to safety and health of workers at work, although the lighting requirements as specified usually fulfil safety needs.

2 LIGHTING DESIGN CRITERIA

The main parameters determining the luminous environment are the luminance distribution, the illuminance level and uniformity, the limitation of glare, the directionality of light (modelling), the colour appearance and colour rendering, and the degree of flicker [1][2]. The luminance distribution in the field of view controls the adaptation level of the eyes. A well balanced luminance distribution (sudden changes should be avoided) is needed to increase the visual acuity, the contrast sensitivity, and the efficiency of the ocular functions. The illuminance and its distribution (on task and surrounding area) have a great impact on how quickly, safely, and comfortably a person perceives and carries out a visual task. The illuminance values specified in the standards [1][2] are maintained illuminances over the task area on the reference surface, which may be horizontal, vertical or inclined. The task area is defined as the partial area in the work place in which the visual task is carried out. For places where the size and/or the location of the task area are unknown, the area where the task may occur is considered as the task area. The maintained illuminance of the surrounding area shall be related to the maintained illuminance of the task area and should provide a well-balanced luminance distribution in the field of view. For task area illuminances of 100 lx or above the illuminances of the surrounding area are specified as four steps down on the recommended scale of illuminances which was taken from the European standard EN 12665 "Basic terms and criteria for specifying lighting requirements" [3]. The surrounding area is regarded as a strip surrounding the task area in the field of view. The width of this strip should be at least 2 m, but this is usually of no importance for railway or tramway lighting.

Alongside the average maintained illuminances specified for a large number of areas, tasks and activities there are also requirements given concerning uniformities (minimum/average) - and in particular for railway and tramway lighting diversities (minimum/maximum) - [1][2] for task and surrounding areas. For the calculation and verification of illuminance values (minimum, average, maximum) a grid system has to be used which is based on a formula giving the maximum grid cell size dependent on the area dimensions. This formula is equivalent to the equation given in the European standard EN 12193 “Sports lighting” [4].

The colour qualities of near-white lamps are characterised by the colour appearance of the lamp (warm, intermediate, cool) and the colour rendering capabilities expressed in terms of the general colour rendering index R_a. This methodology is the same as used for the lighting of indoor work places [5]. For the recognition of safety colours the light sources shall have a minimum colour rendering index of 20; for specific tasks, areas or activities including railways and tramways minimum general colour rendering indices are given in the schedule of lighting requirements [1][2]. To highlight objects, to reveal textures or to improve the appearance of people (modelling), directional lighting may be suitable. Modelling is the term used to describe the balance between diffuse and directional light; too directional lighting will produce harsh shadows. Lighting from specific directions may reveal details within a visual tasks, increase their visibility and making the task easier to perform. Unfortunately there are no measures given in the standards [1][2], only verbal descriptions.

3 EVALUATION OF GLARE

Glare is the sensation produced by bright areas within the field of view and my be experienced either as discomfort or disability glare [1][2]. The glare directly from the luminaires of an outdoor lighting installation shall be determined using the CIE Glare Rating (GR) method according to CIE publication 112:1994 [6]. For a given observer position and a given viewing direction (2º below the horizontal) the degree of glare is dependent on the equivalent veiling luminance produced by the luminaires and the equivalent veiling luminance produced by the environment in front of the observer. The veiling luminance caused by the lighting installation is calculated according to the Holloday formula. The veiling luminance of the environment is approximated; i.e. it is assumed to be 3,5 % of the average luminance of the area under considerations [6]. If no particular observer positions and viewing directions are specified, the glare rating should be computed at the illuminance grid positions at 45º intervals radially about the grid points with the 0º direction parallel to the long axis of the task area [1][2]. On platforms observers should be positioned in a regular grid covering one or several luminaire spacings with viewing directions along the platform and at ±15° / ± 30° against the long axis.

Regarding the disability glare possibly experienced by vehicle drivers there are no limits specified in the standards [1][2]; it only states ‘avoid glare for vehicle drivers’. If the situation of a train driver e.g. entering a station is considered to be similar to the position of a car/lorry driver moving along a road, the threshold increment concept - usually applied in road lighting - could be used to evaluate the disability glare. For a given train driver position (midst of a track at a specified height) the veiling luminance can be calculated, and using the average track luminance as the adaptation luminance (next to a platform as 10% of the average platform luminance) the threshold increment could be determined. It has been proven that installations with luminaires suitable to minimize also the light pollution will produce threshold increments smaller than 10% [7].

4 OBTRUSIVE LIGHT

Obtrusive light is defined as light, outside the area to be lit, which, because of quantitative, directional, or spectral attributes in a given context, gives rise to annoyance, discomfort, distraction or a reduction in the ability to see essential information. The time after which stricter requirements (for the control of obtrusive light) will apply, often a condition of use of lighting applied by a government controlling authority, e.g. the local government, is called curfew [1][2][8]. To safeguard and enhance the night time environment it is necessary to control obtrusive light which can present physiological and ecological problems to surroundings and people. To evaluate the effects of obtrusive light from outdoor lighting installations the methods described in CIE Publication 150:2003 [8] have been included in the standards [1][2] for the lighting of outdoor work places. For the different environmental zones E1 to E4, i.e. natural, rural, suburban, and urban, limits are specified for pre- and post-curfew hours in terms of maximum vertical illuminances on properties, of maximum luminous intensities of individual light sources into potentially obtrusive directions, of maximum average luminances of facades and signs, and of maximum upward light ratios. Furthermore the maximum values of threshold increments for users of nearby roads are considered.

Railway stations are located in all of the different environmental zones E1 to E4. Using luminaires for direct illumination at relatively low mounting heights (and no high pole lighting) will not cause problems in terms of vertical illuminances on buildings, of luminous intensities in potentially obtrusive directions, and of the proportion of the luminous flux emitted above the horizontal. The possible reduction of light levels dependent on passenger volume [1][2] - sometimes even switching off during hours of guaranteed non-operation of trains - is a further measure to reduce light pollution particularly in dark (natural zone E1) or low brightness (rural zone E2) areas. Application of energy efficient lighting systems using lamps with higher efficacy, ballasts with lower losses, and luminaires providing higher utilization factors platform will also help to reduce pollution, obtrusive light, and sky glow.

5 LIGHTING REQUIREMENTS FOR RAILWAYS AND TRAMWAYS

In the schedule of the lighting requirements a large number of areas, tasks, and activities are listed including airports, building and industrial sites, harbours, parking areas, petrochemical industries, power and water plants, railways, saw mills, and shipyards [1][2]. The requirements for railways and tramways are specified in part 12 of table 5: “Lighting requirements for areas, tasks, and activities”. For the specific areas, tasks, and activities requirements are given in terms of average maintained illuminances, uniformities, glare rating limits, and colour rendering indices. For open platforms e.g. there are three different levels of requirements dependent on the type of train or services and on the number of passengers, with a fixed minimum colour rendering index R_a of 20; for covered platforms there are two different levels of requirements dependent on the type of train or services and on the number of passengers, with a fixed minimum colour rendering index R_a of 40. In addition special attention has to be paid to the edge of the platform and to the avoidance of glare for train drivers. The listed minimum values of illuminance, uniformity and diversity [1][2] are a kind of harmonized average values reflecting current European practice. The dependence of the lighting requirements on the type of train or service and passenger volume gives great flexibility and allows e.g. for a reduction of the illuminance level at night time when only a small number of passengers are expected under nominal condition. As the recommended illuminances for the tasks are given as maintained illuminances the design should take into account an appropriate maintenance factor. The maintenance factor to be applied depends on the characteristics of the lamp and control gear, the luminaire, the environment, and on the maintenance programme. For the elaboration of a maintenance schedule it is recommended to follow the methods described in the CIE guide on the maintenance of outdoor lighting systems [9].

5 ENERGY EFFICIENCY OF PLATFORM LIGHTING

Lighting requirements in general concern the quality criteria illuminance level, luminance distribution, glare limitation, modelling, colour appearance, and colour rendition. Besides these photometric criteria special attention is paid to the costs of acquisition, installation, maintenance, and operation of the lighting system. Here it is of particular interest to what extent the total costs could be reduced by utilising lamps with higher efficacy, ballasts with lower losses, and luminaires with higher light output ratios and/or more appropriate luminous intensity distributions The ratio of the achievable illumination level, expressed in terms of an average illuminance on a reference surface (the platform), to the necessary electric power depends on the selected lamps, ballasts, and luminaires as well as on the luminaire layout. For lamps and ballasts there are appropriate measures, efficacy and ballast-lamp circuit power respectively, which serve as a basis for the evaluation of energy efficiency. However, for luminaires the obvious measure, the light output ratio, is not a suitable quantity, as there exists no relationship to the achievable illumination level [10]. The energy efficiency of a particular luminaire in a given layout can be evaluated using the utilization factor platform (UFP). The utilization factor platform is defined as the ratio of the total flux received by the reference area of a platform to the total lamp flux of the installation. If the value of the utilization factor platform is close to the light output ratio of the luminaire there is the risk that the uniformity limits are not met and/or the illuminance along the platform edge is insufficient. Values of the utilization factor platform small compared with the light output ratio of the luminaire indicate not only a poor performance but also the tendency to a higher light pollution as a larger amount of the luminous flux is spread around and not concentrated on the area to be lit. For the selection of appropriate luminaires – covering all requirements concerned – a comprehensive platform lighting design table could be regarded as a useful design tool.

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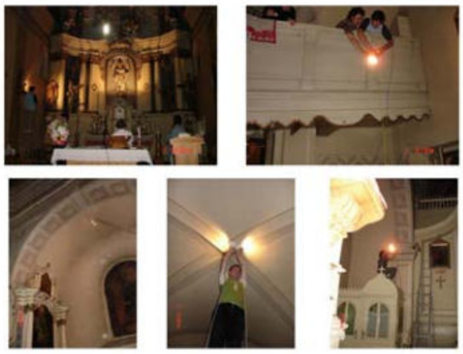
STUDIU DE SOLUȚII PRIVIND ILUMINATUL BISERICII REFORMATE DIN STR. KOGĂLNICEANU CLUJ-NAPOCA

SZABÓ Elisabeta, **ZÁGONI Csaba, OLTEAN George**
S.C. PIEME S.R.L., Cluj-Napoca, Romania

La demararea studiului am pornit de la experiența noastră din domeniu:

– biserica Calvaria din Cluj

– biserica Franciscană din Odorheiu Secuiesc



– biserica evanghelică din Deal Sighișoara

– biserica reformată din Daia

– biserica ortodoxă „Sf. Gheorghe" din Lupșa

– biserica iezuită „Sf. Ignațiu" din Cluj-Napoca

– etc.

Tematica iluminatului bisericii reformate din str. Kogâlniceanu se referă la:

- iluminatul interior, care să permită citirea in navă și cor;
- păstrarea lustrelor existente, proiectate de renumitul arhitect Kós Károly precum și aplicele artistului Furmann Károly, iluminatul realizat de acestea fiind îmbunătățit prin schimbarea surselor de lumină.

După studierea posibilităților de amplasare a aparatelor de iluminat am procurat aparatajul necesar pentru iluminatul de probă: reflectoare asimetrice cu sursă cu halogenuri metalice de 400 W.

Prezentăm câteva dintre încercările efectuate:

La un unghi de înclinare de 45 grade spre interiorul navei s-a constatat efectul de orbire si umbre nedorite pe pereți.

În toate cazurile se vor constata accentuarea coresounzătoare a bolților şi elementelor decorative.

Înaintea definitivării propunerii pentru iluminatul bisericii, am consultat reprezentanții beneficiarului şi renumiți specialişti ai monumentelor istorice:

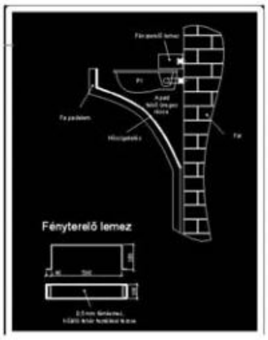
- d-na arh. Éva Eke
- dl. ing. Ádám Maksay
- dl. dr. arh. Virgil Pop

Consultația a condus la completarea tematicii inițiale:

- Tablourile şi blazoanele de pe pereți vor fi protejate de efectele luminii;
- Se va renunța la cele patru aparate de iluminat pentru bolțile din dreptul uşilor laterale, nefiind posibilă instalarea corespunzătoare ale acestora. Modificarea nu va afecta uniformitatea iluminării bolților bisericii.

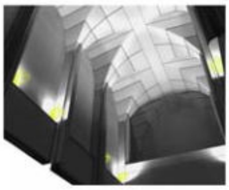
Am pregătit propunerea şi am supus-o analizei beneficiarului.

Detaliu privind instalarea reflectoarelor şi a plăcii de protecție împotriva efectului luminii asupra tablourilor şi blazoanelor.



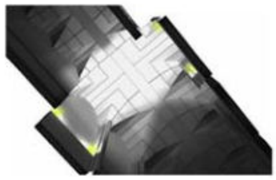
Din analiza de soluții au rezultat 6 secvențe pentru iluminatul bisericii:

Secvența „A"

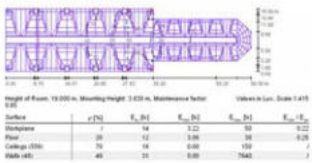


Iluminatul navei cu opt aparate.

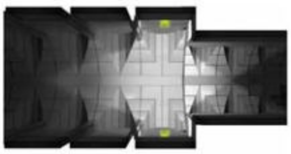
Secvența „B"



Iluminatul bolții de peste altar cu patru aparate.

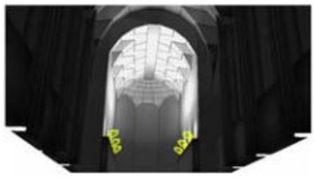


Secvența „C"



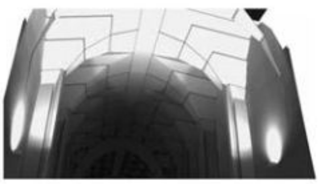
Iluminatul bolții cu două aparate de iluminat.

Secvența „D"

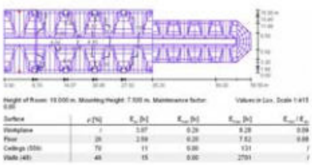


Iluminatul corului cu şase aparate de iluminat.

Secvența „E"



Iluminatul bolții de peste orgă cu două aparate de iluminat.



Secvența „F"

Iluminatul bolții de peste orgă cu două aparate instalate pe prima pereche de stâlpi apropiați.

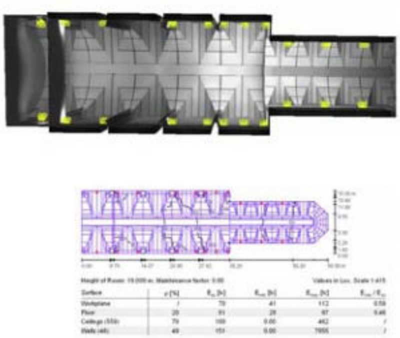
Aparatele de iluminat propuse sunt:

- reflector asimetric cu sursă cu halogenuri metalice de 400 W, culoare 4000 K, având flux luminos de 32000 lm – pentru secvențele A,B,C,D,E;

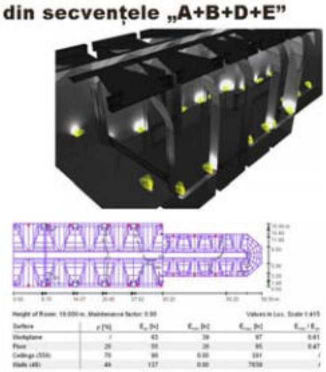
- reflector asimetric cu sursă cu halogenuri metalice de 150 W, culoare 4000 K, având flux luminos de 12000 lm – în cazul secvenței F.

Prin combinarea secvențelor pot fi realizate diverse scenarii de iluminat.

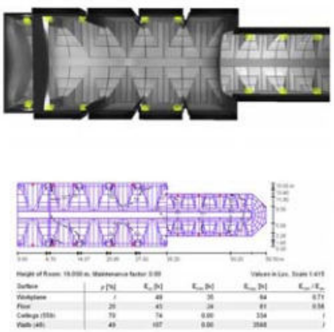
Scenariu compus din secvențele „A+B+C+D+E”



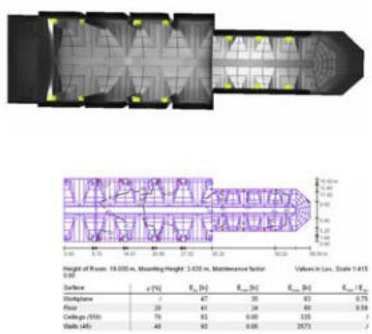
Scenariu compus din secvențele „A+B+D+E”



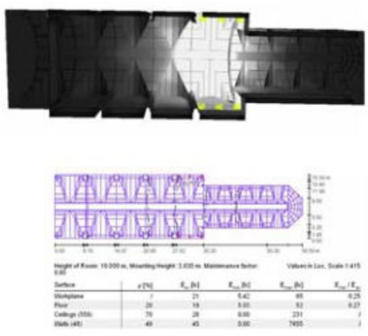
Scenariu compus din secvențele „A+D+E”



Scenariu compus din secvențele „A+D”



Scenariu compus din secvențele „B+C”



Beneficiarul a ales, pentru etapa I a investiției, instalarea aparatelor de iluminat pentru scenariul “A+D+E+F”.

Prezentăm detalii din proiectul tridimensional pentru iluminat, care a avut rol esențial în luarea deciziilor finale cu beneficiarul:

Prima parte prezintă propunerea completă, a doua pe cea pentru etapa I.

Proiectul tridimensional s-a elaborat pentru toate scenariile pentru a face posibilă luarea deciziilor etapelor ulterioare.

În încheiere precizam că proiectul instalațiilor electrice se va elabora pentru soluția completă, astfel etapa I poate fi oricând completată fără intervenții, numai prin instalarea aparatului de iluminat.

WINDOW WITH TWO FUNCTIONS, APPLICATION OF SOLAR TEHNOLOGY

ŞERBAN Daniela
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ABSTRACT

In the last years various materials and manufacturing methods have been developed to created different solar cells. Until now, all of solar cell types have been developed based on the flat surface. But flat solar cell panel has an inconvenient, the amount of energy extract from the sun depends on a certain angle. Two years ago a group of scientists resolved this problem by developing a new way to captures sunlight by a spherical micro solar cell that captures sunlight three-dimensionally. Including this spherical micro solar cells and connect them, inside a thin transparent resin sheet has obtained a flexible transparent module which can be used as a solar power generation cell sheet. The paper present an additionally function for a window on which was applied a flexible transparent module with such spherical solar cells.

SPHERICAL MICRO CELL – BASIC CONCEPT

A solar cell power generation system can produce electricity directly anywhere there is light. Sunlight is captured by a solar cell not only as direct sunlight but also as light diffused by clouds and as light reflected from buildings. The quantity and energy of sunlight as incident light at a solar cell varies according to the positions of the sun, weather conditions and the objects around that reflect sunlight.

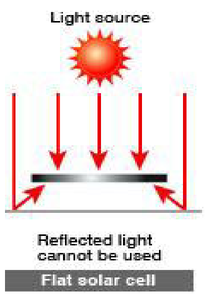

Figure 1 Reflected light on flat surface cell *Source: www.kyosemi.co.jp*

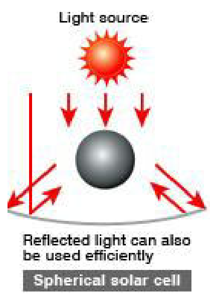

Figure 2 Reflected light on spherical surface cell *Source: www.kyosemi.co.jp*

It cannot be said that solar cells with a flat light reception surface can sufficiently meet these conditions.

The basic concept of a spherical solar cell is that a spherical sunlight reception surface can capture the light in all directions and increase its power generation capacity and thus it can minimize output fluctuations even under direct sunlight and even when the angle of reflected incident light changes.

Spherical cells characteristics:

- small, measuring about 1mm to 2mm across;
- enabling the creation of modules in many different shapes, as well as transparent and flexible modules;
- cells can be connected in series or in parallel;
- cells are durable;
- high-voltage modules can also be anticipated;
- and their material is recyclable.

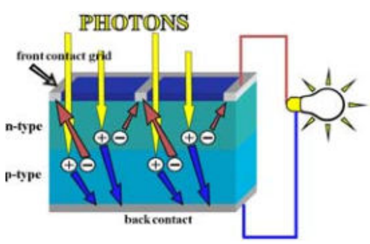

Figure 3 Cross section of a flat solar cell *Source: www.specmat.com*

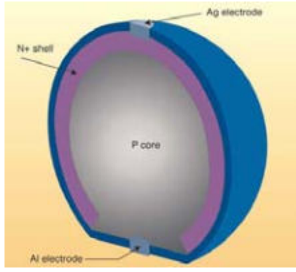

Figure 4 Cross section of a spherical solar cell *Source: www.kyosemi.co.jp*

The two scheme show that the structure of solar cell is the same, the diference is the sunlight reception surface. Conventional solar cells invariably have a flat light reception surface and pn junctions parallel to the light reception surface.

TRANSPARENT AND FLEXIBLE MODULES

Two or more cells can be put together to form a module with greater output by series or parallel connection according to the required voltage or amperage.

By arranging solar cells at appropriate intervals for lighting see-through, solar flexible modules can be created.

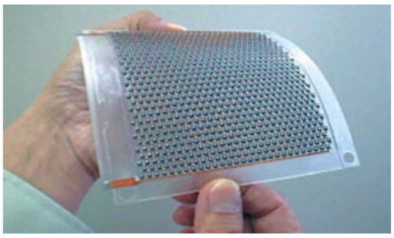

Figure 5 Flexible Module with spherical micro solar cell . *Source: www.kyosemi.co.jp*

APPLICATIONS

Because the modules are very flexible and allow all kinds of arrangements, can covered completely building exteriors, including windows, facades or roofs. From different futures aplications, one of the most useful for the human society it's seem to put these modules on building windows surfaces. Including solar spherical cells in transparent surfaces offer better power generating possibilities than including these cells in building materials for facades or roofs.

In the next paragraph is presented an application of this type of solar module, that can be applied on the windows.

We know that the average power per surface unit is 5.9 mW/cm^2 (*source: www.kyosemi.co.jp*) than we can obtain the average power generated by covered surface with solar spherical cells.

For example, if we have a double window (like in the figure 6) with the following dimensions: 75cmx120cmx2 windows, supposing that we covered only 30% from the window surface with solar spherical cells we get :

$$0.3x75 \text{ cm} \times 120 \text{ cm} \times 2 \text{ windows} = 5400 \text{ cm}^2$$

covered surface which generates

$$5400 \text{ cm}^2 \times 5,9 \text{ mW/cm}^2 = 31860 \text{ mW} = 31,8 \text{ W}$$

As we can see, the window becomes a power generator of 30 W which can ensure the required energy for 30 W bulb, that can be used for night lighting.

Personalized design of modules is possible, taking into account the voltage constraints, respectivelly amperage necessary, also the serial or parallel cells connections. Modules that are more aesthetic can also be produced depending on the arrangement of solar cells and their external design.

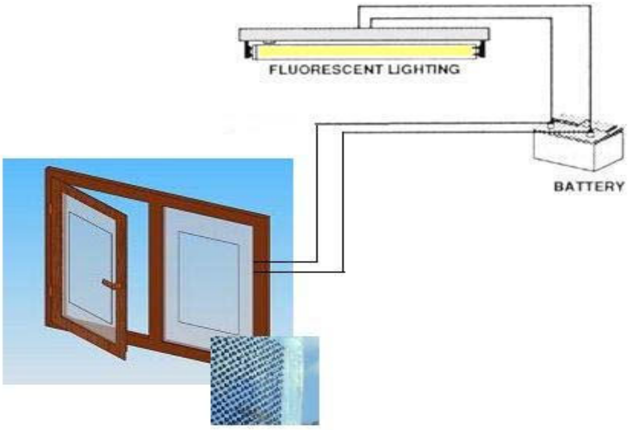

Figure 6 Windows with solar module – action chart

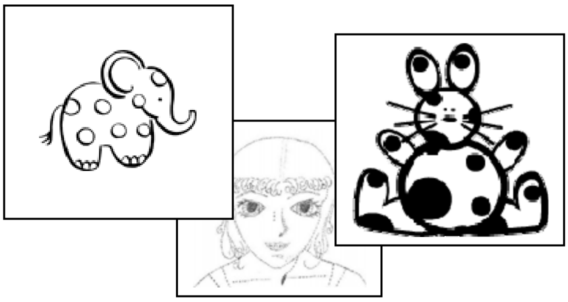

Figure 7 Example of drawings created by dots. *Sources: anonymus internet*

The designers can design different applications in a variety of shapes and in a wide rang of voltage. They also can choose from a variety of different models of dots arrangements . There is a constrain, output power declines with increasing transparency (decreasing cell density). But by adopting different types of model arrangement will can maintain efficiency.

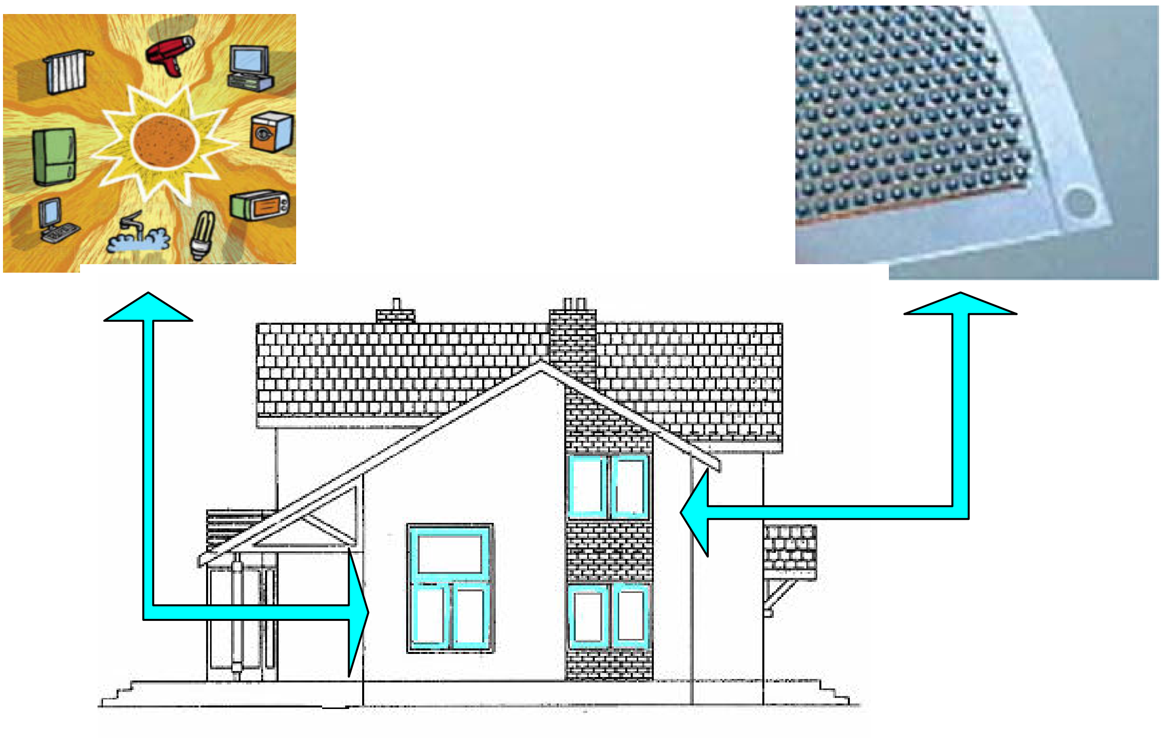

Figure 8 Example of house equipped with windows with solar module

In order to increase the light reception surface area the diameter of a spherical solar cell should be reduced. Thus, the decreasing of the volume for the spherical cell leads to a raise for the efficiency of used material and therefore this method can be integrated in the environmental friendly product category. The spherical cell is made in principal by silicon, so that there is no need to worry about the depletion of resources or an adverse effect of waste on the environment

The generated energy can be used for interior or exterior illumination of the building or for small appliance with energy reduced consume. In the future, the development of these solar modules by increasing the generated power it will open the new range of power applications.

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ACKNOWLEDGEMENTS

Kyosemi Corporation began to develop Sphelar® technology as its new business project nine years ago. In 1998, the company opened the microgravity utilization laboratory within the plant and has since stepped up the development of Sphelar cells as well as advanced optical semiconductor devices used for optical communication. with subsidies from the new energy and industrial technology development organization (NEDO), Kyosemi continued to conduct tests for commercializing Sphelar cells until 2003. the company has also filed about 30 patent applications, including basic patents for semispherical sphelar cells in 1994 and *spherical flexible see-through sphelar sheet* and *dome-style sphelar module sphelar cells* in 1996. (Nataka J, 2006)

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DAYLIGHT AVAILABILITY AS A KEY PARAMETER FOR SUSTAINABLE BUILDING DESIGN: THE CASE OF GREECE

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ABSTRACT

Nowadays several strategies have been developed in order to exploit the daylight and enhance visual conditions indoors. However, these techniques cannot always be implemented successfully, since the dense urban fabric of modern cities often prevents daylight from reaching deep into the spaces. Thus, it is very important to both analyze daylight availability in the region, as well as to investigate the effect of the obstruction's characteristics on the determination of indoor daylight conditions and the energy requirements for lighting. The implementation of such a study in the Greek region forms the main objective of this paper, the steps and the findings of which are presented below analytically.

1 INTRODUCTION

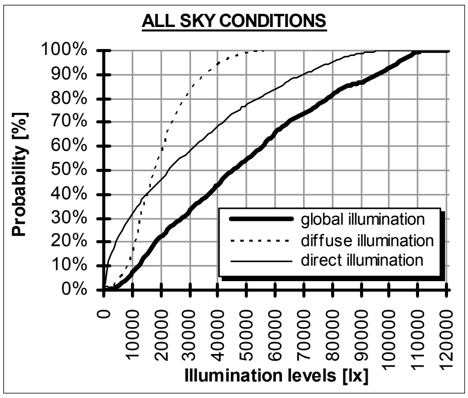
Under the frame of "sustainability" and in a world newly concerned about carbon emissions, global warming and sustainable design, the use of natural light in buildings has become an important strategy for improving energy efficiency by minimizing lighting, heating and cooling loads. However, the integration of common or advanced daylight strategies at each phase of the building design requires information regarding the daylight climate of the region and the distribution of illuminance on a regional, as well as a seasonal basis. All daylighting strategies are based on the utilization of the luminance distribution from the sun, sky, buildings and ground. Their performance is influenced by the availability of daylight, which is determined by the geographical location of the building, as well as by the conditions immediately surrounding the building, i.e. the presence of obstructions. It is therefore essential to investigate the daylight climate of the region along with the impact of the obstructions surrounding the site, in order to optimise the design of the building's façade and enhance indoor daylight conditions. These two essential issues form the objectives of the current paper. It involves the study of daylight availability in the ambient environment for the Greek region and the implementation of its results on the prediction of indoor daylight levels in relation to the urban fabric layout.

2 DAYLIGHT AVAILABILITY ON THE AMBIENT ENVIRONMENT FOR THE GREEK REGION

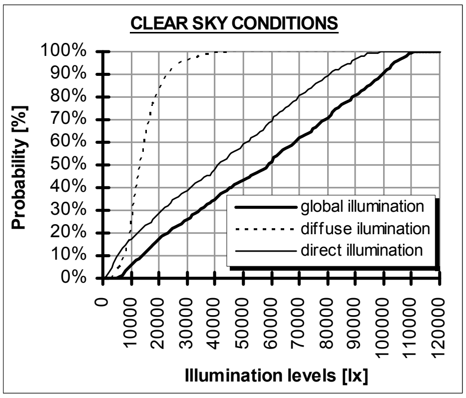
The study of daylight availability in the Greek region was considered necessary, since basic daylight data are not available for most regions of Greece, as well as for many areas worldwide. The National Observatory of Athens (N.O.A.) is the only research establishment in Greece, which has a long and complete solar illuminance database. For the study of daylight availability, N.O.A. has provided climatic data of 5 years (1996-2000). More specifically, 14603 hourly mean values of global and diffuse irradiance, global and diffuse illuminance, relative humidity, air temperature and atmospheric pressure were used for the analysis. All data were subjected to the quality control recommended by C.I.E. After the quality control there were 13275 "safe" data sets of irradiance and illuminance, 35% of which were observed under clear sky conditions. The frequency of overcast sky was found approximately equal to 18%, while the remaining referred to intermediate sky conditions.

Daylight availability was derived as the cumulative frequency of global, diffuse and direct illuminance on an annual and seasonal basis. Figure 1a shows the probability to observe global, diffuse and direct daylight illuminance lower than a datum level on horizontal plane during the year. The x-axis refers to the illumination level intervals, while on y-axis the cumulative frequency of their occurrence is plotted. According to the diagram, there is a probability of 22% to observe values of global illumination lower than 20klx during the year. For the same level of illuminance, the probability for direct and diffuse daylight is equal to 46% and 60% respectively. In general, during the year global illuminance is distributed over a greater range and direct illuminance is higher than diffuse.

By comparing daylight availability in Athens with relevant data from other European cities [1] it is derived that there is a higher probability to observe high global illuminance values in Athens than at



a.



b.

Figure 1 The probability to observe values of global, diffuse and direct illuminance lower than a datum level in Athens during the year under all sky conditions (a) and under clear sky conditions (b).

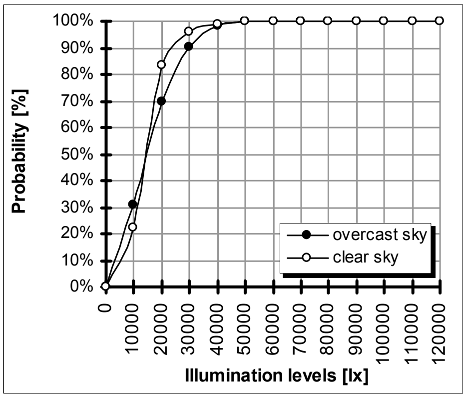


Figure 2 The probability to observe values of diffuse illuminance lower than a datum level on a horizontal plane in Athens during the year under overcast and clear sky conditions.

other northern cities. For example, a global illuminance lower than 20klx is exceeded for only 50% at Aberporth, UK, compared with 22% at Athens [2]. The higher daylight availability in Athens can be attributed to the limited appearance of overcast sky conditions in Athens compared to northern European regions and to the extended sunshine probability during the year [3].

Figure 1b indicates the availability of global, diffuse and direct illuminance under clear sky conditions. The curves for global and direct illuminance have a narrower inclination than that of Figure 1a, demonstrating that global and beam daylight reach much higher levels under clear sky conditions. On the contrary, the range of diffuse illuminance is limited, since under clear skies the scattering of radiation is confined. This becomes more obvious by comparing the availability of diffuse daylight prevailing in Athens during overcast and clear sky conditions (Figure 2). Under clear sky conditions the direct component of solar radiation prevails; therefore it could be expected that at each wavelength the attenuation of global radiation would follow the attenuation of beam radiation due to the absorption and scattering processes encountered in the atmosphere, though to a lesser extent [1]. Rayleigh scattering by air molecules depends on the wavelength and affects mostly the visible radiation. Furthermore, the dust and the particulate matter suspended in the atmosphere reduce direct radiation (Mie scattering). The overall effect of these mechanisms is the reduction of beam radiation reaching the earth and the consequent increase of the diffuse component and is more evident under overcast sky conditions. Therefore, the probability to observe values of diffuse illuminance higher than 20klx under clear skies is lower than that during overcast conditions. Lower values of diffuse illuminance occur more often under clear skies; such values are observed during early morning in summer.

3 DAYLIGHT AVAILABILITY IN INTERIOR SPACES FACING OBSTRUCTIONS

The achievement of visual comfort is the most critical task involved in the analysis of indoor conditions, since the perception of the visual environment is subjective, relative and pertinent to age, gender and the time of day or year. However, the adequacy of lighting levels can be easily estimated and is directly related to the use of indoor space. Therefore, most of the European countries have incorporated recommendations for minimum illuminance values for different activities taking place indoors in their building regulations. For residences or offices the recommended lighting levels range from 300lx to 500lx, regarding the activity to be performed.

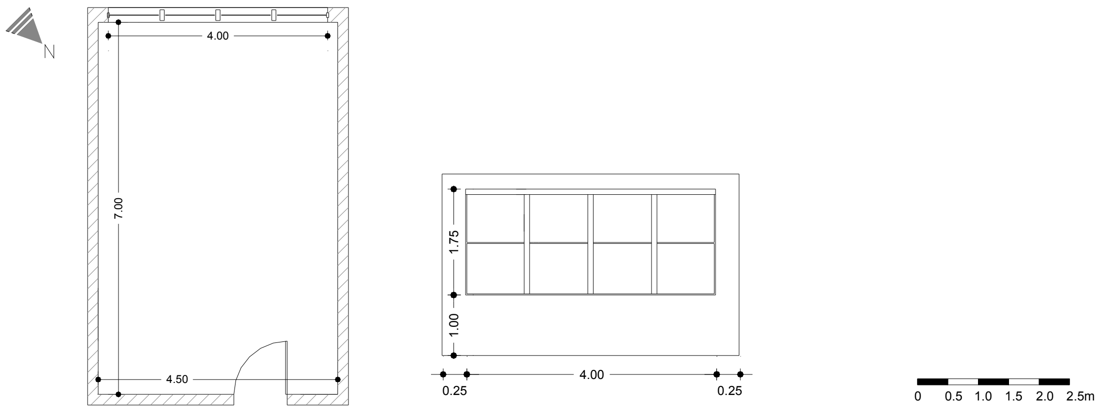


Figure 3 Schematic plan and view from the interior of the room considered as the reference case for the study of the effect of the urban fabric layout on indoor daylight conditions.

Since the quantity and quality of available daylight varies significantly with the hour of the day, time of year and meteorological conditions, the indoor daylight conditions are very often assessed through the estimation of daylight factor. But when studying the adequacy of daylight or the energy consumption for lighting, it is very important to enquire whether the minimum requirements of illuminance are fulfilled, by multiplying the daylight factor with the horizontal illuminance of the ambient environment and compare the resulting value of indoor illuminance with the recommended values.

Therefore, studies of the availability of daylight in the ambient environment, such as the one presented above, could be the basis for the prediction of daylight autonomy in interior spaces; that practically represents the time period, during which the requirements for lighting are fulfilled with the mere use of natural sources and gives an indication for the energy conservation accomplished with different daylight techniques. Since under real conditions the density of the urban fabric prevents the total exploitation of the available daylight outdoors, it was considered worthwhile to evaluate the impact of surrounding buildings on the determination of illuminance levels and daylight autonomy indoors. The study involved the analysis of the major parameters, which influence the indoor illuminance distribution in case of obstructed sky view, i.e. the view angle and the reflectance of the obstruction.

3.1 Methodology of the parametric study

The analysis of the urban fabric layout impact on indoor daylight levels was performed as a parametric study, by comparing the conditions prevailing in a reference case study interior space as well as in models with different site geometry. A room with design features representative for office buildings was adopted as the reference case for the study (named R_0). It is of rectangular plan (5,00x7,00m) and is lit by one window (4,00mx1,75m, windowsill height: 1,00m), which represents a 20% ratio of window to floor area (Figure 3). The window is covered with a conventional glazing (visible transmittance T_v=85%.) The reflectance of the surfaces covering the floor, ceiling and walls was considered equal to 18%, 30% and 30% respectively. The reference model (R_0) has unobstructed view to the sky dome.

On the basis of the reference case study 10 more models were developed, which were identical to the former as regards the geometrical and optical characteristics, while their view to the

Table 1 The geometrical and the optical characteristics of the obstructions facing the models of the parametric analysis.

Model's name	Obstructed sky view percentage	Height of obstruction above the windowsill	Reflectivity of the obstruction's façade, r_o
R_o	-	-	-
R_1	20%	2,3m	30%
R_2	20%	2,3m	50%
R_3	40%	5,0m	30%
R_4	40%	5,0m	50%
R_5	60%	9,0m	30%
R_6	60%	9,0m	50%
R_7	80%	16,0m	30%
R_8	80%	16,0m	50%
R_9	100%	45,0m	30%
R_{10}	100%	45,0m	50%

sky dome was gradually obstructed by the opposite buildings. The distance between the obstruction and the examined models was considered equal to 8,0m, representing the conditions usually met in the dense urban fabric of many Greek cities. The estimation of the obstruction's height for each case was based on the percentage of obstructed sky view in conjunction with the view angle of sky from the windowsill of reference model R_0. Moreover, taking into account the geometrical characteristics of the window of the reference model R_0, it was found that the sky could not be seen from its windowsill, if the angle between the upper boundary of the opening and the work plane exceeds 80^o. On the basis of that value, the heights of the obstructions facing the models of the parametric study were estimated, assuming that for each case the obstruction blocked the sky view at a rate ranging from 20% to 100% and increased gradually by 20% (Table 1). Apart from the geometrical characteristics of the obstruction, the reflectance of the external obstruction was also investigated (Table 1). For each percentage of obstructed sky view, the reflectivity of the obstruction was set equal to 30% and 50%. These values are usually met on external vertical facades of different colors, ratios of transparent to opaque elements or accumulation of dirt.

The daylight conditions prevailing on the work plane of the models were assessed through the use of a simulation tool (PHOTOsynthesis) developed by the author [4]. The accuracy of the results was evaluated both by in situ measurements and simulations with computer programs of acknowledged reliability (i.e. Adeline). The study was focused on overcast sky conditions.

3.2 The effect of obstruction characteristics in the determination of indoor daylight conditions

Figure 4 illustrates the mean daylight factor estimated for the reference model R_0 and the models R_1 to R_{10}. Every pair of columns represents the daylight conditions for a particular rate of obstructed sky view, while each column of the pair corresponds to 30% and 50% reflectivity of the obstruction's façade respectively. It is obvious that daylight levels decrease as the visible part of the sky becomes

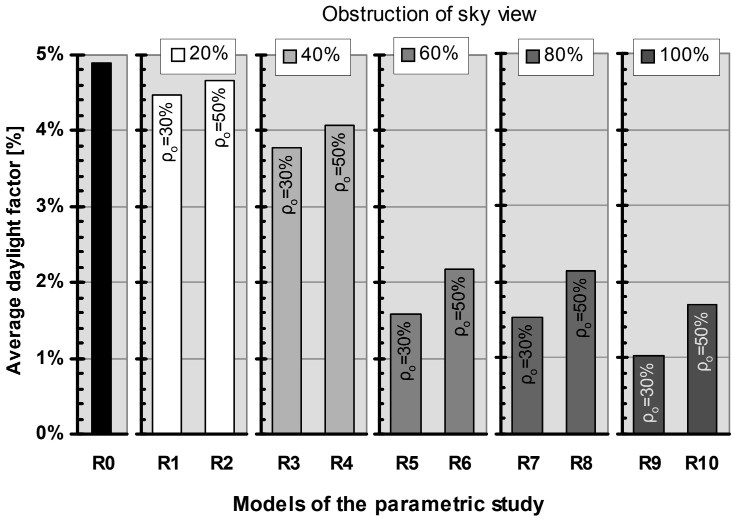


Figure 4 The average daylight factor on the working plane of models R_0 and R_1-R_{10} of the parametric analysis in relation to the rate of obstructed sky view and the reflectivity of the obstruction's facade.

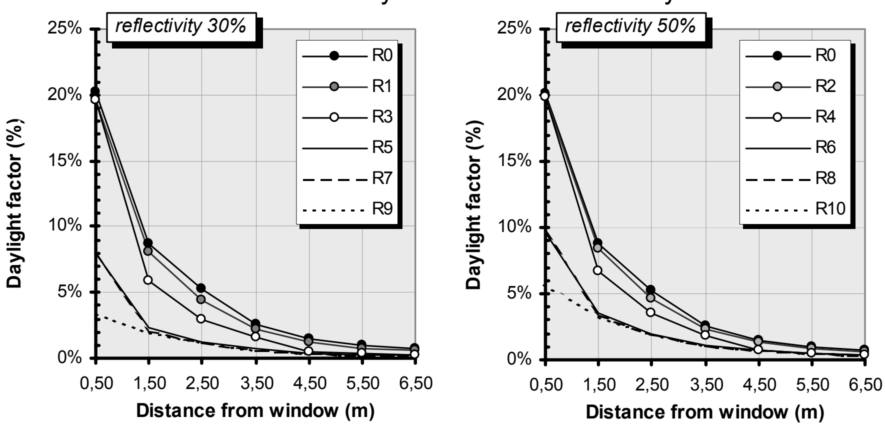


Figure 5 The distribution of daylight factor across the working plane of the reference model R_0 and the models R_1-R_{10} of the parametric study.

confined. However, no analogy between the reduction of daylight factor and the blocked sky view is observed. On the contrary, the value of average daylight factor is dramatically reduced when the rate of obstructed sky view exceeds 60% (models R_5 to R_{10}).

Furthermore, when the obstruction is of low reflectivity (30%) and blocks the sky view at a rate of 40% (model R_3) compared to the reference model, the average daylight factor is reduced at a rate of approximately 20% in relation to the reference model R_0. By increasing the impact of the obstruction to 60%, the proportional decrease of the average daylight factor of model R_5 is equal to 65%. When the sky view is totally blocked (model R_9), the average daylight factor is reduced at a rate of 80% and reaches very low levels. The changes in the average daylight factor due to the percentage of obstructed sky view follow the same pattern in the case of obstructions with higher reflectivity; however, they range in lower levels varying from 4% to 65% with respect to the obstruction's height.

Additionally, the thorough observation of Figure 4 leads to the conclusion that the difference in average daylight levels between the models that face obstructions with similar geometrical, but different optical characteristics becomes more intense as the view of the visible sky reduces. In more detail, the proportional difference of daylight factor in models R_1 and R_2 equals 4%. For the next pair of models (R_3 and R_4), which face obstructions of the same height but of different reflectivity, the proportional change in daylight factor is doubled, whereas when the sky view is obstructed by 60% the relative alteration goes up to 37%. The maximum difference (65%) is observed when the obstruction blocks the view of sky from each point of the working plane. This pattern leads to the conclusion that the reflectivity of the obstruction's façade is more critical as the view to the visible sky is eliminated. On such situations, the sky component of the daylight factor is reduced and proportionally the contribution of the externally reflected component becomes more important for the determination of daylight conditions indoors. However, under overcast conditions the low levels of exterior daylight and sky luminance are not usually adequate for covering the needs for interior lighting; in fact, this is often the fact for apartments located at the first floors of high buildings with openings facing narrow streets.

The disproportion in the reduction of daylight factor can be explained through Figure 5, which shows the distribution of daylight factor across the models R_1, R_3, R_5, R_7 and R_9 (various angles of sky view obstruction, reflectance of the obstruction's façade r_o=30%). From the figure it can be depicted that points of the working plane of models R_0, R_1 and R_3 located at a distance of 0,5m from the front wall appear to have similar values of daylight factor. In these cases the obstructions block the view of the lower parts of the sky, whose luminance is lower than that near zenith and consequently the daylight factor remains practically unaffected. The difference of daylight factor gets significant up to 2,50m from the window wall; for points located further on the depth of the room the change becomes more moderate and diminishes at points near the back wall.

The daylight factor on the points adjacent to window wall of models R_5 and R_7 is much lower than that observed in the reference model R_0, since the sky view is obstructed at a considerable extent. For these models, the distribution of daylight factor ranges on similar levels, although the obstruction of sky view has different rates, indicating that the daylight received in the interior is mainly determined by the externally and internally reflected daylight, while the contribution of the sky component is low. On the case of higher reflectivity of external obstruction (Figure 5), the daylight factor follows the same pattern of distribution across the models, only at higher rates. The downward displacement of the curves of models R_6, R_8 and R_{10} is more obvious due to the direct and essential interrelationship between the indoor daylight conditions and the amount of daylight that is reflected on the surface of the opposed buildings.

3.3 The effect of the obstruction characteristics in the use of artificial lighting

The estimation of the daylight factor on the working plane of the models shows the levels of daylighting and indicates the potential of lighting adequacy under the most critical conditions. However, when environmental aspects are concerned, it is very important to predict the total time, during which the needs for lighting should be covered by artificial means.

The estimation of the potential use of artificial light can be achieved by combining the results of the study for daylight availability (Figure 2) and the distribution of the daylight factor on the working plane of the examined models. This is illustrated in Figure 6, where the percentage of time with autonomy in daylight is plotted across the case study space R_0 and the models of the parametric analysis (R_1-R_{10}) assuming that daylight autonomy is achieved at a point of the working plane when the illuminance at that point equals or exceeds 500lx. For the case of low façade reflectance (30%) the required illuminance can be achieved for the majority of working time only at the zone of models R_1 and R_3, which is close to the window wall (distance<1,4m). Models R_5, R_7 and R_9 need artificial lighting approximately during the whole working time, indicating that the presence of high obstructions make them particularly energy consuming. Evidential of the amount of energy required for lighting model R_9

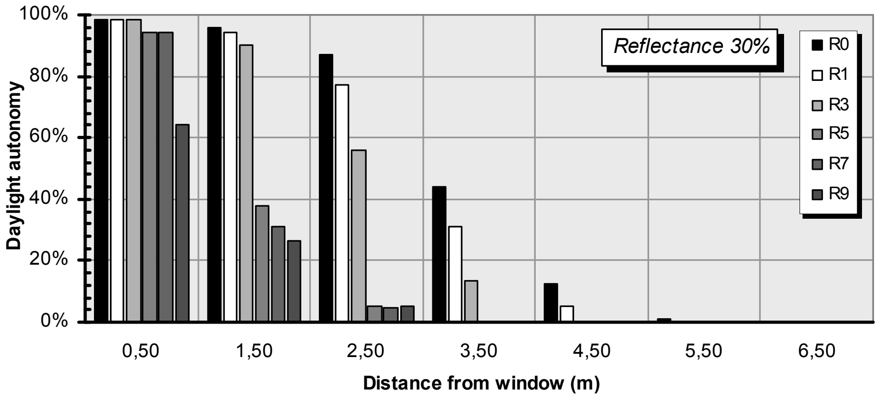


Figure 6 The percentage of time, during which there is autonomy in daylighting across the working plane of the models of the parametric study, in the case of 30% reflectivity of the obstruction's façade.

is the fact that even for areas near the window the use of artificial lighting is necessary for up to 35% of working time.

When the obstruction is of higher reflectivity, models R_2 and R_4 appear to be more daylight autonomous in the zones near the window. Furthermore, the use of artificial lighting in the middle of these models is reduced at a rate of 10% in relation to models R_1 and R_3. The daylight availability on the reference plane increases significantly on the area near the window, however the rest of the plane should be lit only by artificial means.

4 CONCLUSIONS-PROPOSALS

The quantitative approach of the above analysis showed that the availability of daylight in building interiors is significantly affected not only by the daylight climate of the region, but also by the geometrical characteristics of the site surrounding the building. The deep canyons that are usually met in the centres of modern cities often result in poorly lit indoor environments. Towards the enhancement of daylight conditions in spaces of the urban fabric layout a lot can be done for new buildings, through their proper displacement with respect to the surroundings and the careful design of their façades, but not much can be implemented for existing constructions. In the latter case, refurbishment activities, which have actually increased in the industrialized countries in the last few decades, should address the exploitation of daylight in order to meet today's requirements. For example, daylight-redirecting systems, such as glass prisms, holographic elements and laser-cut panels, can improve the distribution of light to interior spaces. For heavily obstructed façades, the implementation of daylight systems that collect diffuse light from the upper sky vault, such as anidolic ceilings, can also be very useful.

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DIMENSIUNEA CULTURALA A LUMINII

Discutie intre arhitecti

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EXPLICATIE

Discutiile despre lumina se petrec tot mai mult intre tehnicieni si designeri. Schimburile de idei se pot realiza la nivelul tehnologic, la cel conceptual sau intre aceste sfere care se slujesc una pe cealalta. De data aceasta va propunem un brainstorming intre arhitecti, la nivel teoretic si cu conexiunile specifice gandirii acestora. Autorii au convingerea ca tot mai mult devine important ca mecanismele gandirii si dezvolatrii proiectelor, modul de lucru, procesele intime ale inspiratiei si inventicii sa fie relevate si sa ofere noi surse si resurse. Axiomele evidente se pot amesteca printre idei nastrusnice si invers, creatia artistica si excelenta avand intotdeauna legaturi cu viata si universul cotidian al creatorilor. Este o discutie intre arhitecti despre lumina.

ARIHITECTURA SI LUMINA

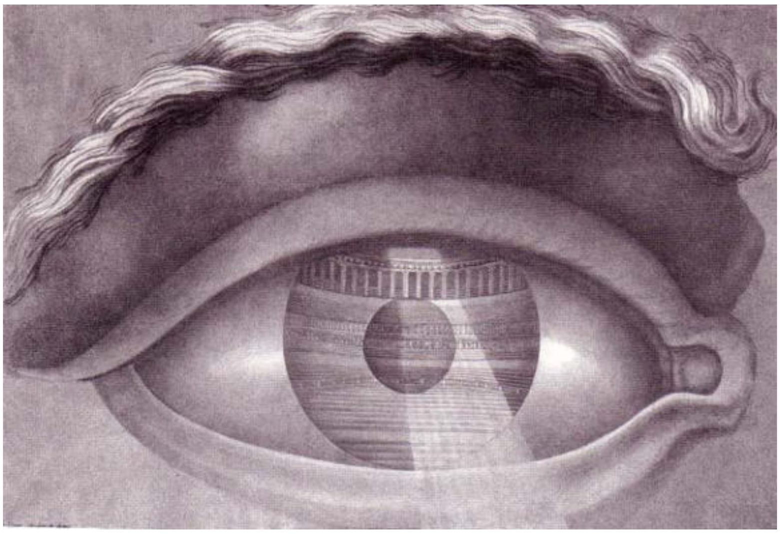

Figura 1 Claude Nicolas Ledoux. Auditoriul teatrului din Besancon reflectat intr-un ochi. 1804.

Arhitectura este o problema de decodificare. Primul pas spre a o interpreta si a o intelege este perceptia. Arhitectura este perceputa senzorial ca o complexitate nesimultana, desi avand o multitudine de compozitii statice. Toate simturile participa la perceptia arhitecturii intr-un concert in care vizibilul este principalul furnizor. Sinteza perceptiei este realizata mental.

Pierre von Meiss lansa un avertisment in « De la forme au lieu » prin care spunea ca arhitectura este in primul rand vizuala si kinestezica.

In lectiile sale de arhitectura, adunate in « L' apprentissage du regard », ucenicia privirii, Dominique Spinetta, atrage atentia asupra luminii ca element de delimitare a locului, de demarcare intre interior si exterior, uneori vaga.

Perceptia arhitecturii este culturala.

Aceeasi arhitectura inspira diferit privitorii, perceptorii sai. La fel ca o carte recitita peste timp, sau un film revazut cu alta atentie la detalii, arhitectura revizitata este perceputa diferit. Complexitatea perceptiei, dar mai ales capacitatea de a sintetiza, conecta si decodifica a privitorului se imbogateste, se modifica, ceea ce face ca nici un loc sa nu mai fie a doua oara la fel.

Lumina este indisolubil legata de perceptia vizuala, capatand rolul principal in perceptia arhitecturii.

TIPOLOGII DE LUMINA

Vorbind despre lumina distingem cele doua categorii considerate mai mult dupa sursa si nu dupa efectul obtinut: lumina naturala si lumina artificiala. Cum ar fi sa clasificam lumina altfel decat dupa sursa, mai degraba dupa impresia pe care o realizeaza ? Lumina naturala poate fi transportata si filtrata in mod artificial de sisteme diverse, oglinzi, conducte de lumina, panouri prismatice, astfel incat efectul din spatiu sa fie comparabil cu cel al luminii artificiale. In anumite situatii nu poti distinge lumina naturala de cea artificiala. De asemenea lumina artificiala poate fi folosita in configuratii care imita lumina naturala, ascunzand sursa, difuzand-o prin materiale interpuse.

Lumina artificiala poate fi interioara sau exterioara dupa pozitia sursei fata de un spatiu de referinta, dar mai poate fi exterioara perceputa din interior sau interioara perceputa din exterior. Acest tip de efecte poat fi controlate in oarecare masura sau numai speculate arhitectural.

Fotografii de arhitectura speculeaza efectele simultane de lumina naturala crepusculara si de lumina artificiala perceputa din exterior prin transparenta. Lumina mai poate fi directa sau indirecta, proprie unui aparat de iluminat, vizibila sau disimulata, ascunsa, prezenta numai prin efect.

Lumina este informatie vizuala directa sau codificata. Ecranul luminos, reclama text sau imagine sunt reductibile la digit sau pixel.

Dorim sa discutam despre dimensiunea culturala, dar ce alta dimensiune mai are lumina ?

Cea mai la indemana clasificare este functionala:

Lumina de siguranta este cea care permite orientarea, circulatia discreta si evacuarea in caz de pericol. O putem denumi « minima lumina ».

Lumina de confort este cea necesara vederii pentru diferite activitati, fiind orientata si dozata corespunzator. O putem denumi « lumina optima ».

Lumina reprezentativa, comemorativa, care atrage atentia sau innobileaza este « lumina simbolica ».

Lumina comerciala este puternica, contrastanta, este « lumina atractiva ».

Lumina publica urbana este uneori feerica, aranjata pentru a marca evenimente, « lumina de sarbatoare ».

Lumina spectacolului, festivalului, de pe scena, sau opera artistica in sine, acompaniata sau nu de muzica sau alte manifestari este « lumina spectaculara ».

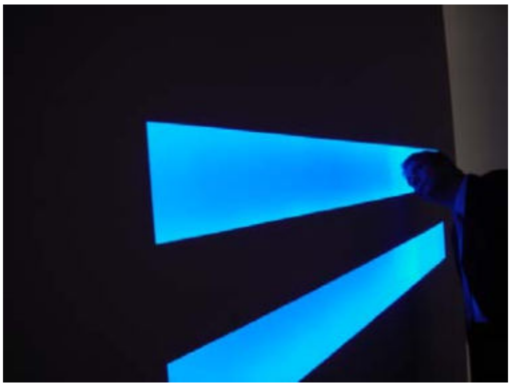

Figura 2 Zumtobel light showroom. Dornbirn, Austria.

Fiecare forma in sine isi produce efectele in context, care are o importanta deosebita. Conteaza dozajul si adecvarea. Absenta minimei lumini sau inadecvarea celei optime sunt inacceptabile. La fel excesul de lumina simbolica, sarbatoreasca sau spectaculara le atenueaza sensul prin concurenta. Cum s-ar mai percepe o lumina rosie de la o intrare, intr-un oras luminat in intregime in rosu intens ?

ADECVARE SI NEADECVARE LUMINOASA

Lumina poate fi adecvata sau nu. Adecvarea insemana adaptare, subordonare arhitecturii si nu in ultimul rand o relationare inteligenta.

Lumina poate insa sa preia conducerea, sa accentueze sau sa corecteze.

Neadecvarea luminii are acelasi efect cu nereusita artistica a arhitecturii. Neadecvarea functionala este evidenta si cu consecinte deranjante. Neadecvarea stilistica, culturala este insa mai greu de evitat. Lumina centraza, confera statutul de personaj principal, in spatiul comun ca pe scena. Lumina evidentiaza prin stralucire.

Clasic si contemporan

Lumina clasica este difuza, eleganta, rafinata, bine dozata. Simuleaza lumina naturala, fiind proiectata de sus. Lumina clasica traieste in corp pe masura, lampile fiind obiecte de arta in sine. Lumina clasica este sincera, descinzand din aparate (lampi) cara isi aloca in spatiu o pozitie centrala, vizibila, ca parte din compozitia spatiilor. In clasic artificialul nu se confunda cu naturalul, sisitemele fiind distincte si diferite. Arta luminii se compune din sursa si efect. Tiffany sau Lalique sunt nume care au capturat in formelel legate de lumina topirea lumanarii, scurgerea picaturilor. Impresionismul din pictura seamana din punct de vedere tehnic uimitor cu descompunerea in pixeli de pe monitoare, cu flatarea extremelor si despartirea in 1 si 0, alb si negru, lumina si umbra.

In contemporaneitate efectul conteaza, lumina indepartandu-se de obiect, devenind spatiu, pelicula, perdea, perete, cer. Culorile sunt artificiale si se prezinte astfel. Lumina este esenta abstracta, controlata precis, conturata si colorata. Uneori lumina taie spatii, delimiteaza ferm sau marcheaza treceri bruste. Lumina artificiala indeparteaza de real conducand spre supranatural sau science fiction. High tech este expresia viitorului din prezent.

Mark Fisher este un arhitect care lucreaza in zona spectacolului. Scenele proiectate de el pentru U2, The Rolling Stones sau Pink Floyd sunt construite din lumina si informatie. Lumina poate fi proiectata digital, gandita, simulata si anticipata. Lumina este reversibila, modificabila, modulabila si testabila. Corectiile sunt posibile si binevenite. Ajustarile pe teren confera celei mai inalte tehnologii o componenta de mestesug, de lucru cu mana.

Lumina isi cere timpul sau, care este mai mult al distractiei, al relaxarii, deci opus muncii, cotidianului.

Cerul instelat este augmentat de artificii, un termen care se autorevendica ca artificial.

Figura 3 Zaha Hadid si Patrick Schumacher. Vortex. Zumtobel, Dornbirn.

PUTINA ANTICIPATIE

Podoabele luminoase ar putea fi ceea ce confera figurii umane un nou tip de stralucire. Aura din reprezentarile sfintilor ar putea fi modelul unei bijuterii speciale.

Mersul pe strada ar putea sa-ti ofere experiente de interactiune cu lumina, de la joc pana la creatie efemera.

Un parc tematic al luminii ar putea fi un loc de joaca al viitorului, asa cum azi se dezvolta tot mai mult ludicul cu apa, sau substituirea artistului prin karaoke.

Ne intrebam cum ar fi ca artistii strazii care colecteaza monezi cantand la instrumente muzicale sa recurga la spectacole cu lumina ?

Ce fel de lumina ar putea lua locul lumanarilor de pe tortul aniversar ?

Cum ar arata primul apus de soare artificial in aer liber ?

Ce fel de sporturi s-ar putea dezvolta pe baza de lumina ?

Daca in locul drapelelor care flutura am folosi lumini care sa aiba aceeasi semnificatie ?

Randamentul spectacular, ludic si monumental al luminii este imens. Calitatea efemera o face cu atat mai asemanatoare si asociabila cu muzica.

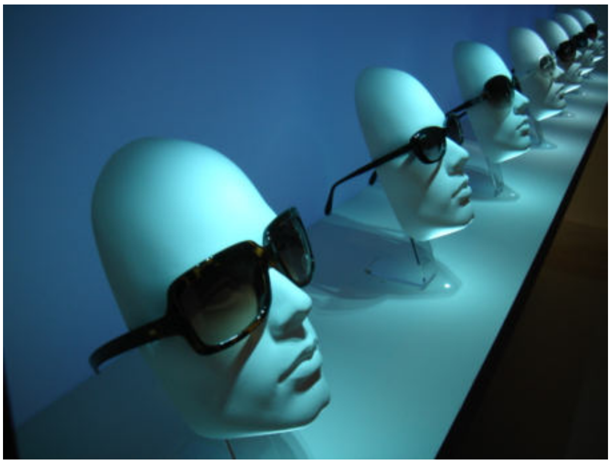

Figura 4 Zumtobel light showroom, Dornbirn.

Lumina poate sa se apropie de propria personalitate. Individualitatea si individualizarea este o preocupare a celor mai multi care au depasit starea de necesitate primara. Se personalizeaza imaginea, se cauta un stil propriu, fie ca este al propriei aparente sau a spatiilor si marilor accesorii care ne inconjoara, casa autoturismul, peisajul luat in posesie. In aceste ecuatii lumina poate juca un rol nelimitat in ipostaze.

SI IN FINAL

Lumina de la capatul tunelului va fi intotdeauna frumoasa pentru ca e dorita.

Pe langa spectacole, targuri, conferinte, inaugurari, cum ar arata o zi mondiala a luminii ca celebrare a dimensiunii culturale a acesteia pe care am reamintit-o aici ?

Figura 5 Declaratia arhitectului Ortner despre lumina. Zumtobel light showroom. Dornbirn. “Lumina este cel mai important material de constructie. Construim tot restul imprejurul ei.”

Asa cum stilurile literare, ale artelor plastice sau ale arhitecturii se subordoneaza unor generice culturale, expresie a spiritului vremii sau componente ale pluralitatii contemporane, lumina poate fi si ea dimensionata cultural si integrata in curente artistice. Putem vorbi de clasic si contemporan, de postmodern sau kitch, de pop sau science fiction. Si totusi lumina singura, izolata, in absenta spatiului sau evenimentului nu isi are sensul. Imaterialitatea ei o face dependenta de materie. Lumina lumineaza ceva, se ataseaza si se adreseaza. Nu poti privi doar lumina ci efectele ei si mai ales nu poti lumina lumina coerent, chiar daca in practica se mai intampla astfel de nonsensuri. Intre produs de serie si experienta unica irepetabila lumina acopera o gama intinsa de formule si aplicatii. Este inevitabila. Acest lucru intareste nevoia de a fi tratata cu atentia cuvenita potentialului sau cultural. Atributul cultural nu trebuie sa ramana ocazional si rar. Nevoia dimensiunii artistice se regaseste in fiecare casa, in fiecare persoana, in fiecare loc. Acea individualitate si personalizare de care vorbeam se realizeaza mai ales prin optiunea culturala a fiecaruia.

INFLUENCE OF GEOMETRICAL PARAMETERS AND RULE REQUIREMENTS ON THE OPTIMUM LIGHT DISTRIBUTION OF THE STREET LUMINAIRES

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ABSTRACT

The formulation and the results of the most effective light distribution of the optimization task of street luminaries are described in the paper. The European requirements to the quantitative indexes and rules are introduced as limiting conditions. Received optimum solutions are graphical visualized and the influence of different parameters of optimum solutions are studied. The program product MATLAB 6.5 is used for solving of the task and appropriate software is applied.

Keywords: lighting, streetlighting, calculation

INTRODUCTION

During the designing process of street lighting, it is necessary to observe the following two conditions:

- to meet the requirements of the norm values of the lighting indicators for street lighting installations [1, 2, 3];
- to ensure maximum efficiency of the street lighting system.

By its nature the designing process appears to be a solution of an optimization task. The efficiency of the obtained solution is strongly affected by the luminaire light distribution. This is the reason to consider the light distribution as a determinative factor for the degree of usefulness of the luminous flux.

The present work defines the optimization task for obtaining of regulated luminance values in the normalized standard valued with minimum luminous flux emitted by the luminaire.

BACKGROUND AND SOLUTION OF THE OPTIMIZATION TASK

The light-technical task for determination of the optimum light distribution of the street luminaire is formulated by using a street lighting system with the following parameters:

- width of the illuminated street surface - *W*;
- height of luminaire installation - *H*;
- distance between the poles – *S;*
- The reflection characteristics of the roadway surface at different observation angels (corresponding to the different traffic rates) are determined.

Our approach is directed to looking for such a luminaire light distribution which helps to ensure the achievement of quantitative and quality normalized indicators at the lowest value of the necessary luminous flux of the light source – $\mathbf{\Phi_{LS} = min.}$

For resolving this task, it is necessary to solve the optimization task under the following limiting conditions:

-The average luminance on the observation area should be larger or equal to the normalized value according to the [Eq.1, 2, 3]

-Total luminance uniformity should be larger than the preliminary given values, according to [1, 2, 3]

- The glare criterion should not be larger than the preliminary given value in accordance with [1, 2, 3]

- The maximum light intensity related to the luminous flux 1000lm should not be larger than the preliminary given value (technological limitations)

The indicated imitating conditions were selected during the process of resolving the optimization task, as all other limitations that do not significantly affect the optimum solution were rejected.

In equations [5, 6, 7, 8 and 9] the above optimization task is formulated as a linear one. The reason is to facilitate the solution.Under real conditions, the defined optimization task is not linear because the luminance,uniformity and glare are nonlinear functions of the luninaire light distribution parameters. By these reasons the solution of the present optimization task is defined and resolved as a nonlinear one.

Formulation of the optimization task

During the formulation and resolving the task for optimum light distribution an considerable problem appears to be the inclusion of the light distribution function. In case, when the task is defined as a linear one, the light distribution is described by discrete values for definite **γ** angle and **C** plane. These values of light intensity are unknown.

Since they are not connected in functional relation, it is possible to obtain the optimum solution with a lot of peaks and falls in the light distribution curve. The subsequent smoothing of the light distribution leads to deformation of the obtained optimum solution.

The approximation of the luminaire light distribution to smooth differential function appears to be a possible solution

Such a solution could be a polynomial function, decomposed by sin and cos degrees, or orthogonal polynomial approximation. [10]

For the selection of an approximation function, it was preliminary selected a family of luminaries characterized by a specific light distribution. A typical example of such a selection is the General Electric luminaire. After the analysis of the luminaire light distribution the approximation function could be presented as follows:

$$\mathbf{f}(\gamma,\mathbf{C}) = \mathbf{exp}\left(\mathbf{d}_0(\gamma_i) + \mathbf{d}_1(\gamma_i)\hat{\mathbf{C}}_j + \mathbf{d}_2(\gamma_i)\hat{\mathbf{C}}_j^2 + \mathbf{d}_3(\gamma_i)\hat{\mathbf{C}}_j^3 + \mathbf{d}_4(\gamma_i)\hat{\mathbf{C}}_j^4 + \mathbf{d}_5(\gamma_i)\hat{\mathbf{C}}_j^5 + \mathbf{d}_6(\gamma_i)\hat{\mathbf{C}}_j^6 + \mathbf{d}_7(\gamma_i)\hat{\mathbf{C}}_j^7\right)$$

where the $\mathbf{d_p(\gamma_i)}$ coefficients are expressed by orthogonal Legendre polynomials and $\hat{C} = \frac{\mathbf{C}}{\mathbf{Max(C)}}$ varies after normalization in the [0.1] /interval/.The index (**i**) is used for designation of a row, and index (**j**) for designation of a column. Respectively, angle γ is related to rows of the light characteristics and angle C is related to the columns of the characteristics.

The coefficient $\mathbf{d_p(\gamma_i)}$ (*p=0, 1, 2, 3, 4, 5, 6, 7*) is of the type presented below:

$$\mathbf{d_p}(\gamma_i) = \mathbf{q_{p1}S_1}(\mathbf{T_i}) + \mathbf{q_{p2}S_2}(\mathbf{T_i}) + \cdots + \mathbf{q_{pm}S_m}(\mathbf{T_i}),$$

Where: $\mathbf{q_{pk}}$ are the unknown factors estimated by the method of smallest (p=0, 1, 2, 3, 4, 5, 6, 7), $\mathbf{S_k}$ – is orthogonal Legender polynomials of rank k (k = 1 …m) , argument $\mathbf{T_i}$ calculated as follows: $\mathbf{T_i} = \frac{\mathbf{2\gamma_i - \gamma(1) - \gamma(n)}}{\mathbf{\gamma(n) - \gamma(1)}}$. The angles γ**(1)** and γ**(n)** present the first and the last value of γ angle. This transformation corresponds to γ angle in the [0, 1] interval.

The orthogonal Legendre polynomials from first to fifteen rank could be presented as follows:

S{1}=1
S{2}= T
S{3}= (3/2)*T^2-1/2
S{4}= (1/2)*T*(5*T^2-3)
S{5}= (35/8)*T^4-(15/4)*T^2+(3/8)
S{6}= (1/8)*T*((63*T^4)-(70*T^2)+15)
S{7}= (231/16)*T^6-(315/16)*T^4+(105/16)*T^2-(5/16)
S{8}= (1/16)*T*((429*T^6)-(693*T^4)+(315*T^2)-35)
S{9}= (6435/128)*T^8-(3003/32)*T^6+(3465/64)*T^4-(315/32)*T^2+(35/128)
S{10}= (1/128)*T*((12155*T^8)-(25740*T^6)+(18018*T^4)-(4620*T^2)+315)
S{11}=(46189/256)*T^{10}-(109395/256)*T^8+(45045/128)*T^6-(15015/128)*T^4+(3465/256)*T^2-(63/256)
S{12}=(1/256)*T*((88179*T^{10})-(230945*T^8)+(218790*T^6)-(90090*T^4)+(15015*T^2)-693)
S{13}=(676039/1024)*T^{12}-(969969/512)*T^{10}+(2078505/1024)*T^8-(255255/256)*T^6+(225225/1024)*T^4-
-(9009/512)*T^2+(231/1024)
S{14}=(1/1024)*T*((-90090*T^2)+(765765*T^4)+3003+(1300075*T^{12})+(4849845*T^8)-(2771340*T^6)-
-(4056234*T^{10}))
S{15}=(-765765/2048)*T^4-(16900975/2048)*T^{12} +(45045/2048)*T^2+ (22309287/2048)*T^{10}+
+(4849845/2048)*T^6-(14549535/2048)*T^8-(429/2048)+(5014575/2048)*T^{14}

These polynomials are used during the approximation of $\boldsymbol{d_p(\gamma_i)}$ coefficients**.** (p=0, 1, 2, 3, 4, 5, 6, 7).

Four variants of approximation of the lighting characteristics are developed.

The variants differentiate by the series of coefficients approximation $\boldsymbol{d_p(\gamma_i)}$ (p=0, 1, 2, 3, 4, 5, 6, 7) by orthogonal Legendre polynomials, namely the choice of *m = 9, 11, 13, 15* .

With an approximation of a polynomial from 7^{th} rank, the accuracy was not satisfying, and with an approximation with a polynomial of a fifteen rank the number of coefficients was larger.

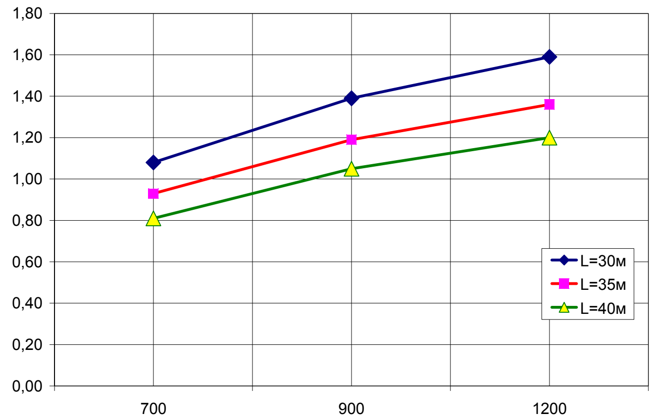
$\Phi\ lamp = \sum\sum I\gamma c\ .\ \Delta\Omega\gamma c = MIN \quad \gamma=0-\pi/2,\ C=0-\pi$
Under following final conditions:
$Lmin / Laverage > Go$
$Emin / Eaver > Geo$
$I\gamma c\ max\ (\Phi lamp=1000\ lm) < Io$
$TI < TIo$ for given values
Where:
L average –average pavement luminance
Lmin is minimum pavement luminance
Φlamp is a luminaire flux
ΔΩγc are *γ* and *c* solid angles
TI – Glare factor.
The limiting conditions are complex functions of unknown functions, as shown below:
$Laverage = 1/M \sum Li$
$Li = f1(I\gamma c)$
$I\gamma c = f2(X_k)$ => X_k are unknown (coefficients ahead the orthogonal Legendre polynomials)
The number of coefficients (the known ones) of polynomials of 9^{th} degree is 72.
The optimization task has t o find out the value of these coefficients, taking as a n initial point the values obtained during the approximation of GE (General Electric) luminaire light distribution
The above optimization task was resolved for the following geometry of the lighting installation.
Distance between the poles: 30, 35 and 40 m;
Width of the roadway 7 and 9 m;
Height of the pole 7 m.
The following values were given to the limiting conditions:
Go =0.4 and 0.5, *Geo* = 0.5 and 0.6, *Io* = 500, 600, 700, 900, 1200 and 1500 cd/1000 lm, *TIo* = 10

For resolving the above optimization task was used the parameter function of MATLAB package. The resolving time for the AMD Athlon 64 Dual Core/3800*MHz processor is from 20 up to 50 minutes for a variant. 80 optimum solutions have been obtained for given various values of limiting conditions. Part of these solutions are presented in Table 1 after results processing This process could be presented as follows:

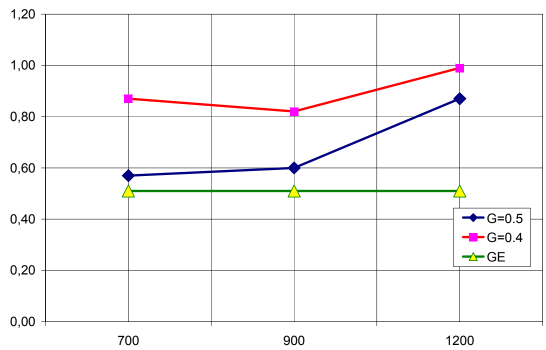
1. On the basis of the obtained optimum solution for the corresponding parameters it is created the light distribution in accordance with the requirements of Publication N 34 of CIE
2. The light distribution is introduced in the catalog of EPS 1 4 3 program and the calculation of quantitative and quality parameters for the lighting installation is performed by varying the given geometry parameters in narrow limits. The used light distribution curve is graphically presented

VIZUAL PRESENTATION OF THE RESULTS OBTAINED

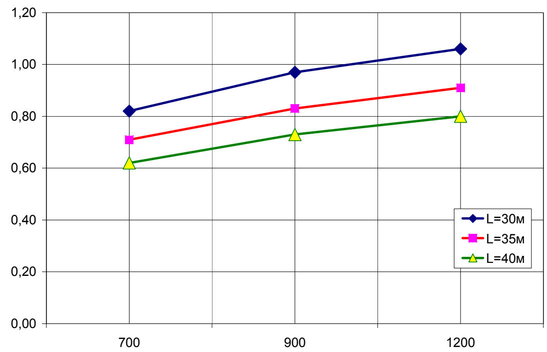
Obtained average pavement luminance cd/sqm (the values are presented on the ordinate axis of the graph) in dependence on the light distribution of the luminaire with the following parameters:
Lamp luminous flux = 6600 lm, depreciation factor -1.3
Given maximum light intensity for 1000 lm conditional flux (the parameter is presented on the abscissa of the graph)
Distance between the poles - *L*= 30, 35 and 40 m
Given glare parameter TI<10%, *G*=0.5
Number of luminaires included in the calculations 2+3
Roadway width =7 m, *hpole* = 7 m
Light distribution № 40, 41, 42



Obtained average pavement luminance cd/sqm (the values are presented on the ordinate axis of the graph) in dependence on the light distribution of the luminaire with the following parameters:
Lamp luminous flux =6600 lm, depreciation factor -1.3
Given maximum light intensity for 1000 lm (the parameter is presented on the abscissa of the graph
Distance between poles *L*= 40 m
Given glare criterion *TI*<10%
Number of luminaries participating in the calculations 2+3
Light distribution № 43, 44, 45

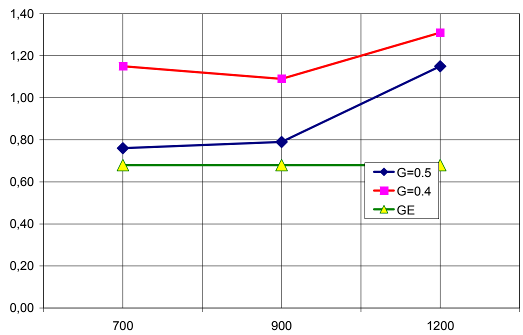


Road width =9 m, *hpole* = 9 m

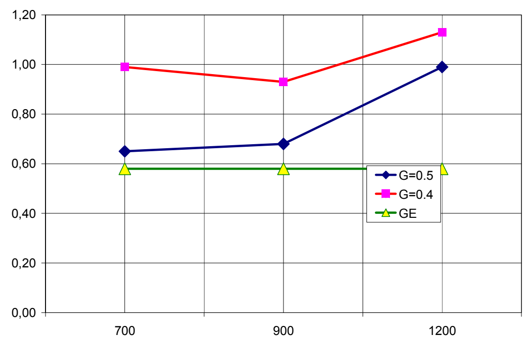


Road width=9 m, *hpole* = 7 m

The obtained average pavement luminance cd/sqm (the values are presented on the ordinate axis of the graph) in dependence on the light distribution of the luminaire with the following parameters:
Lamp luminous flux =6600 lm, allowance coefficient -1.3
Given maximum light intensity for 1000 lm (the parameter is presented on the abscissa of the graph
Distance between poles *L*= 30 m
Given glare criterion TI<10%
Number of luminaries participating in the calculations 2+3
Roadway width =9 m, *hpole* = 9 m



Light distribution № 46, 47, 48



Light distribution № 49, 50, 51

Table 1. Realized average pavement luminance cd/sqm in dependence on the light distribution of the luminaire for the following parameters:
Lamp Luminous flux= 6600 lm, Depreciation factor =1.3

	Road width	Pole Height	Given value	Obtained value	Given value	Obtained value	Obtained value	Obtained value	Obtained	Average
LVK			*Go=Lmin/Lav*	*Go=Lmin/Lav*	*Imax*-1000	*Imax*-1000	*TI* %	*Laverage*	*Laverage*	*Laverage*
№	m	m			cd/1000 lm	cd/1000 lm		cd/sqm	cd/sqm	cd/sqm
								distance *L*=30 m	distance *L*=35 m	distance *L*=40 m
40	7	7	0.5	**0.52**	1200	1200	**9.2**	**1.59**	**1.36**	**1.20**
41	7	7	0.5	**0.48**	900	900	**15.0**	**1.39**	**1.19**	**1.05**
42	7	7	0.5	**0.48**	700	700	**12.9**	**1.08**	**0.93**	**0.81**
43	9	7	0.5	**0.54**	1200	1200	**5.4**	**1.06**	**0.91**	**0.80**
44	9	7	0.5	**0.53**	900	900	**8.6**	**0.97**	**0.83**	**0.73**
45	9	7	0.5	**0.48**	700	700	**8.8**	**0.82**	**0.71**	**0.62**
46	9	9	0.5	**0.48**	1200	1200	**9.2**	**1.15**	**0.99**	**0.87**
47	9	9	0.5	**0.46**	900	900	**9.9**	**0.79**	**0.68**	**0.60**
48	9	9	0.5	**0.59**	700	700	**5.6**	**0.76**	**0.65**	**0.57**
49	9	9	0.4	**0.38**	1200	1200	**9.6**	**1.31**	**1.13**	**0.99**
50	9	9	0.4	**0.37**	900	900	**9.1**	**1.09**	**0.93**	**0.82**
51	9	9	0.4	**0.48**	700	700	**9.2**	**1.15**	**0.99**	**0.87**

CONCLUSIONS

1. For the achievement of light distribution for efficient roadway (street) lighting it is necessary to define the corresponding optimization task. This task is nonlinear because of the luminaire light distribution parameters and its resolving needs the use the methods of nonlinear optimization.
2. Aiming to receive an functional relationship between the light intensity in different directions it is reasonable to simulate by using continuous differentiable function.
3. The selection of an approximation function should help the achievement of a good approximation of light distributions of the existing luminaries.
4. During the resolving of the nonlinear optimization task. it is reasonable to use the light distribution parameters of a highly efficient existing luminaire as an initial point
5. The reduction of the maximum light intensity below 700 cd for 1000 lm conditional luminous flux does not allow the achievement of an efficient solution.
6. The inclusion of limitation condition- for the glare parameter affects very restrictively the light emission in γ = 75 – 90 degree range and diminishes the efficiency of the obtained solution.
7. It is possible to obtain highly efficient solutions for a given value of glare uniformity *Lmin/Lav* > 0.6
8. It is recommended the creation of method of modeling of luminaire optical system. allowing the achievement of light intensity higher than 1200 cd for 1000 lm conditional luminous flux.

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AN IMPROVEMENT OF LUMINANCE DISTRIBUTION OF A LARGE SKY SIMULATOR AT KH UNIVERSITY

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ABSTRACT

Daylighting experiment under real sky condition is difficult due to constantly changing sky condition. As an alternative facility of real sky, the sky simulator have been developed and used to represent the desired consistent sky condition. KH University has developed a large sky simulator. It is hemispherical shape with 6m-diameter and 3.7m-height. 72 halogen lamps with individually dimming controller are equipped in sky simulator. The sky simulator was verified reproducing CIE standard overcast sky by measuring of luminance. This study attempts to represent more qualified standard sky condition with higher luminance condition. Luminance on the inner sky surface were measured and compared with standard value. It is found that the sky simulator can reproduce the exact CIE standard overcast sky with 1.81% of mean difference. Luminance distribution of the sky simulator can be improved by repeated experiment.

Keyword: Sky simulator, CIE Standard overcast sky, Luminance distribution

1 INTRODUCTION

Evaluating daylighting performance has to be considered with various methods in design process and assessed by accurate standard. Scale model measurement as one of the ways of evaluating daylighting performance can assess various shape of space and has high reliability because of consistency of light. Scale model measurement is useful method for evaluating dayligting performance and often selected and used by researchers. Maintaining constant sky condition is essential factor during daylighting experiment. However real sky condition is so various that standard is needed to get a reasonable conclusion. Sky simulator is a daylighting facility that reproduces standard sky condition. For many years, it has been developed and used for daylighting researches at the advanced research laboratories.

KH University has developed a large sky simulator to conduct daylighting study in a constant sky condition [1]. In the previous study, the sky simulator was verified reproducing the CIE standard overcast sky with 4.3% of mean difference in two different sky luminance condition, with 15 lamps on and 72 lamps on [2].

This study is to simulate more accurate CIE standard overcast with higher luminance condition. For the purpose, the voltage was increased and luminous flux and angle of the lamps were controlled to the standard value. CS-100 and ProMetric were used for measuring luminance on the inner sky surface.

2 SKY SIMULATOR AT KH UNIVERSITY

The sky simulator of KH University is sky dome type with 6m-diameter and 3.7 m-height. The hemispherical shell is consisted of 133 insulated steel-skinned parts and the radius of curvature of each part was calculated in order to make completely curved surface. Interior surface was painted white matte finish that possible distribute light uniformly. Light source is halogen lamp. Its consumption is 500 W and luminous flux is 9,500 lm. 72 halogen lamps were installed in 3 rows and 24 lines. With all lamps on, maximum horizontal illuminance is about 9,740 lx and maximum sky zenith luminance is about 3,890 cd/m². The luminance can be adjusted individually by controlling of luminous flux and angle of the lamps. The heated atmosphere in the skydome by halogen lamps was handled with 2 air conditioners and ventilating opening connected outside through round shape flexible duct.

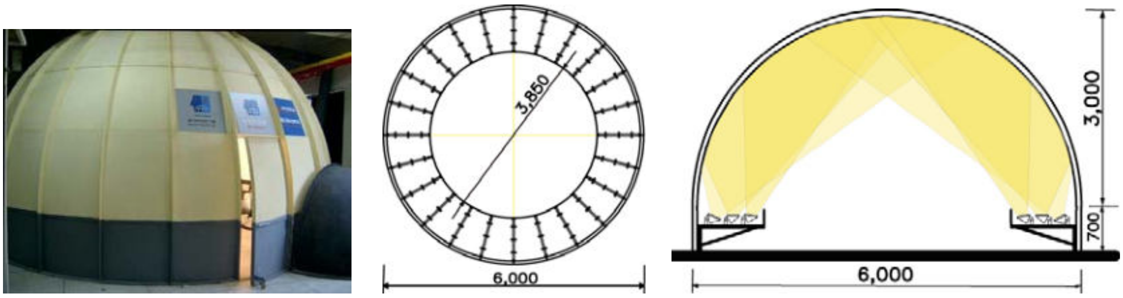


Figure 1 Configuration of KH sky simulator

3 LUMINANCE MEASUREMENT OF SKY SIMULATOR

3.1 Measurement by CS-100

To verify the reliability of the sky simulator luminance measurement of inner surface was carried out as follows. The luminance distribution of the sky simulator was adjusted to CIE standard overcast sky model and measured at 6 angles and 6 directions (Figure 2). Table 1 and Figure 3 show measurement values and comparative values with standard model. Measurement (a) and (b) are the values of the previous studies [2]. It was found that the sky simulator simulated reliable standard sky condition with 4.3% of mean difference and 2.97:1 ratio of zenith luminance and horizon luminance. However it was analyzed that they had high error rate at measurement angle of 54° comparatively. As a result of this measurement, it was found that the sky simulator represents high sky zenith luminance, 3,487 cd/m² and CIE standard overcast sky model with 1.81% mean difference (Table 1). Moreover it has low uniform difference with standard value through all of the measurement angles (Figure 3 (c)).

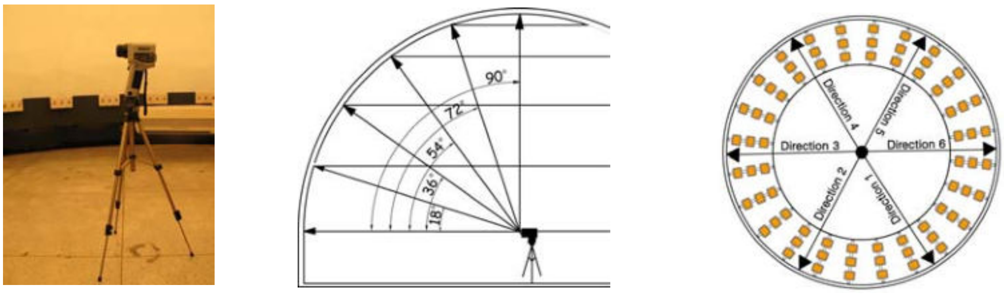
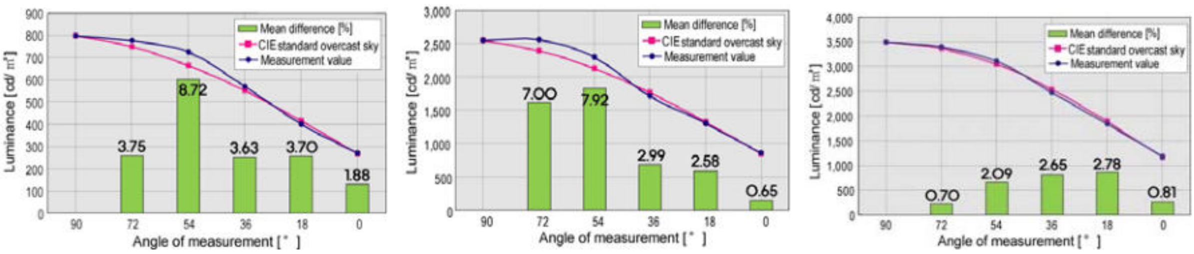


Figure 2 Luminance meter and measuring point

Table 1. Luminance value and error rate with CIE model

	Number of lighted lamps	Zenith luminance / Horizon luminance [cd/m²]	Ratio of zenith luminance and horizon luminance	Mean error rate with CIE model [%]
(a)	15ea (5lines)	798 / 271	2.94 : 1	4.34
(b)	72ea (24lines)	2,550 / 851	2.99 : 1	4.23
(c)	72ea (24lines)	3,487 / 1,172	2.96 : 1	1.81



(a) sky zenith luminance: 798 cd/m² (b) sky zenith luminance: 2,550 cd/m² (c) sky zenith luminance: 3,487 cd/m²

Figure 3 Comparison of measurement value with CIE model

3.2 Measurement by ProMetric

To complement the single point measurement by CS-100, the second measurement was made by ProMetric. ProMetric is digital photometer capable of capturing images and quantitatively analyzing images for light and color characteristics. Compared to traditional equipment that can measure luminance and chromaticity by single point, ProMetric system offers an advantage to measure 1,500,000 points simultaneously. Luminance distribution on inner surface was measured by ProMetric to confirm the visible luminance distribution in addition to verify the numerical value. The inner surface of the skydome was divided into 3 parts from horizon to zenith to evaluate the luminance distribution pattern (Figure 4). The luminance distributions are shown on Table 2. It shows similar luminance values with standard sky model as previous measurement value by CS-100. It was found that luminance pattern distribute uniformly along the inner surface.

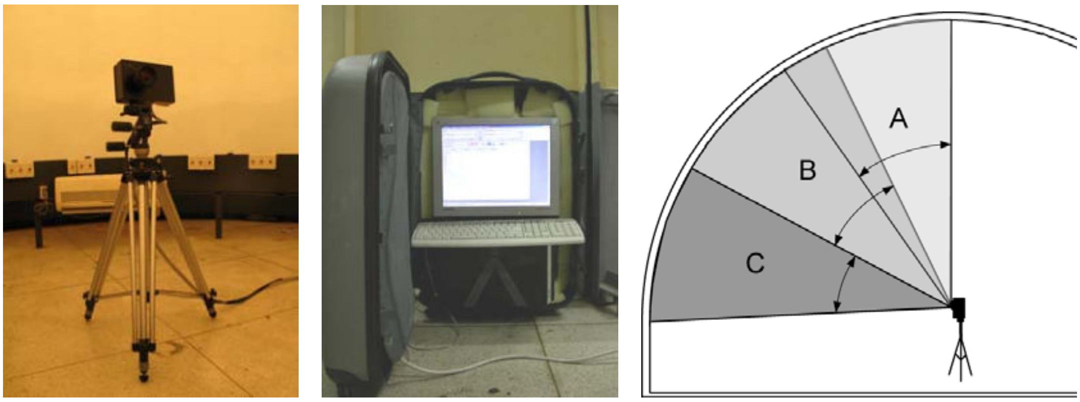
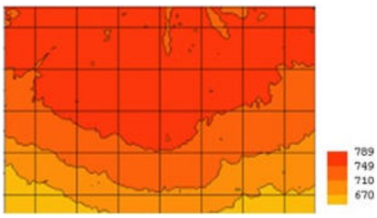
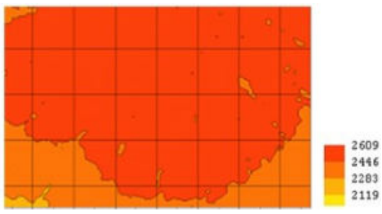
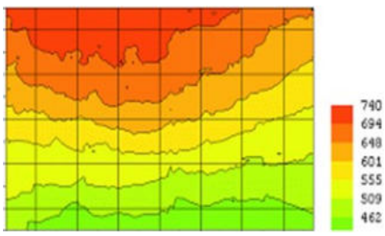
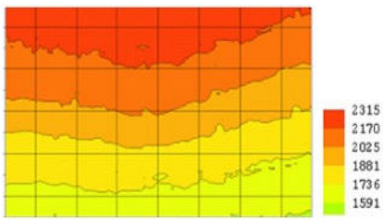
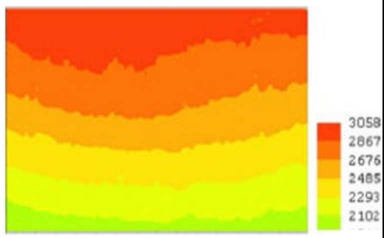
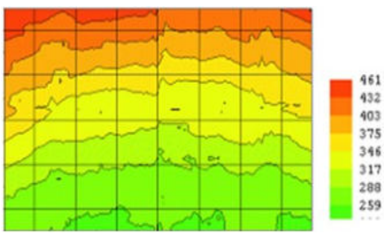
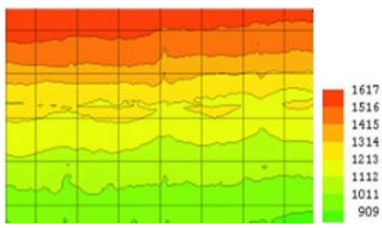
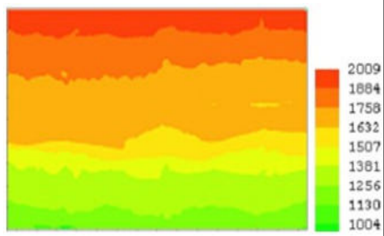


Figure 4 ProMetric and measuring range

Table 2 Luminance distribution by ProMetric

	(a)	(b)	(c)
A			
B			
C			

4 CONCLUSION

Sky simulator is a vital facility for evaluating daylighting performance in scale model experiment. It allows reliable daylighting experiment by simulating standard sky condition such as CIE standard overcast sky or CIE standard clear sky.

KH University has developed a skydome type of sky simulator, 6 m - diameter, which is suitable for the international standard. Dimmer systems are equipped by controlling 72 lamps individually.

The sky simulator was verified luminance distribution in 3 different luminance condition; each zenith luminance was 798 cd/m², 2,550 cd/m², and 3,487 cd/m². It was found that mean difference with CIE standard overcast sky model was 3.5% and verified reproducing reliable sky condition. In particular, the third measurement with highest luminance represent the qualified standard sky condition with 1.81% of difference.

Another luminance measurement was carried out by ProMetric photometer. Luminance distribution acquired as a 2D image was reconfirmed the reproducing standard sky model by distributing luminance pattern uniformly.

As a result of using two kinds of luminance meter, it is fully validated for its accuracy for daylighting research. Under the constant overcast sky condition using the KH sky simulator, reliable daylighting study is expected to be possible.

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THE QUEST OF THE PERFECT LIGHT SOURCE

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ABSTRACT

Light is vital for life: Light sources play an indispensable role to daily life of any Human being. Our World cannot be conceived without light. Quality of life, health and, somehow, urban security related with traffic and crime prevention measures depend on light and on its quality. The lighting industry is an important economic factor in Europe, USA and many Asiatic Countries. All in all, lighting is an important socio-economic factor and lighting system development should be an integral part of any Sustainable Development and of any program of improvement of Quality of Life.

This presentation provides an overview of the present state of research in the science and technology of light sources. Existing technologies and future challenges for the lighting industry will be presented.

1 INTRODUCTION

Currently, more than 30 billion lamps operate worldwide consuming more than 2 650 billion kWh per year (19% of the global energy production world-wide). If, for an industrialised country, this amount is substantial (e.g. about 11% for France, more than 20% for US) it becomes very important for under-development nations for which lighting is one of the major applications of electricity (i.e. 37 % for Tunisia and up to 86% for Tanzania). Furthermore, the annual greenhouse gas (CO_2) due to this energy production is estimated to be in the order of 1 700 million tons. In the next 2 decades, it can be estimated that the need for light sources will increases by a factor between 1 and 2. More efficient light sources would

- limit the rate-of-increase of electric power consumption ;
- reduce the economic and social costs of constructing new generating capacity ;
- reduce the emissions of greenhouse gases and other pollutants.

In fact, an improvement of 25% in the lamp efficacy corresponds to 250 billion kWh per year energy savings as well as 150 million tons less greenhouse gas in the atmosphere.

2 SOME DEFINITIONS

The quality of a light source can only been defined in terms of the application for which it is designed. As the major application of light sources is lighting, the understanding of the "visual environment" is required before any attempt to optimise the light source. This visual environment consists on the light source, the object and the photoreceptor. In fact, "to see", means, using the photoreceptor to detect, to locate and to identify an object illuminated by a light source (Fig. 1).

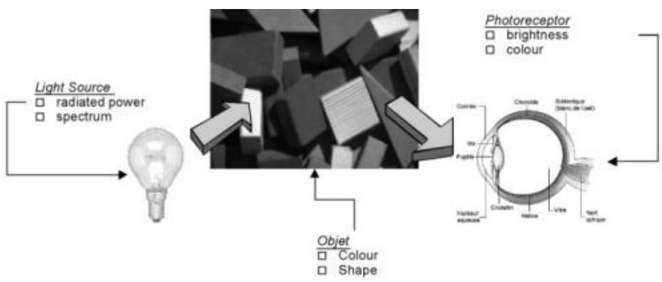

Figure 1 The visual environment

In the triad "source-object-photoreceptor" it is preferable to first examine the second item, the object, because this is a "passive" element with fixed properties. An object is characterised by its shape and its colour. The "colour" is a rather tricky idea because, as we will discuss latter, we "see" colours in our brain only. In fact, objects appear coloured by selectively reflecting or absorbing various wavelengths of light incident upon them. As an example, a red rose appears red to us (this not the case of a bee or a dog…) because it reflects light around 700 nm and absorbs all other wavelengths.

Let now focus our attention to the photoreceptor because its properties largely govern the needed visual properties of sources. In most common cases the human eye is this photoreceptor.

The eye pick up light from the source or the object and transmit the information to the human brain as two different independently perceivable signals: "brightness" and "colour", where colour is further broken down into "hue" and "saturation". The eye perceives different wavelengths and the brain "see" colours. The eye, as photoreceptor, is sensitive to only a narrow band of the electromagnetic spectrum, this band, corresponding to "visible light", stretch from 400 nm (violet) to 700 nm (red). Moreover, it is not uniformly sensitive within this pass band. The sensitivity varies with the illumination level, this is due to the fact two different type of detectors exist in the eye: the cones which perceive colour and necessitate a minimum illumination level of a few candelas per square meter (cd/m^2) and the rods which perceive grey levels corresponding to brightness, they are much more sensitive and faster than cones.

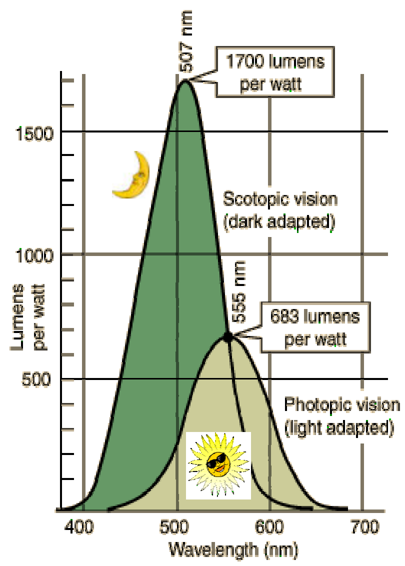

Figure 2 Relative sensitivity of the "standard" human eye under photopic (sun sign) and scotopic (moon sign) vision conditions

Figure 2 shows the relative response of the "standard" human eye as function of the incident wavelength adopted since 1924 by the C.I.E.The first curve (moon sign) corresponds to the eye response under low illumination level, called scotopic vision. The second one (sun sign), represents the receptor's sensitivity under high illumination level, this is the photopic vision. This latter is the only one concerning lighting design because the eye is "light-adapted" than "dark-adapted" under the most illumination levels produced by the man-made light. The brightness sensitivity is related to energy by the fact that at 555 nm (this wavelength corresponds to the maximum sensitivity of the human eye) a radiant watt emitted by the source is equal to 683 lumens (lm). Thus, the lumen should be considered as a "weighted" power unit taking in to account the human eye sensibility.

The light source is characterised by the radiant power and the emitted spectrum. The efficacy of a lamp is more delicate to define; in fact we will distinguish here the "electrical efficacy" to the "luminous efficiency".

For most seeing tasks, colour perception of illuminated objects is important. If a light source has very little energy radiated in the part of the spectrum that the object can reflects then it look rather black (or grey). The Colour Rendering Index (CRI) is a measure of how well the light source reproduce the colours of any object in comparison to a black body radiating at the same "colour temperature". The CRI of a lamp is obtained by measuring the fraction of light reflected from each of a number of surfaces of specific colours covering the visible spectrum. We arbitrary attributed a maximum CRI of 100 to this light source whose most closely reproduce colours.

Depending on the intended applications, commercial light sources will have different rating for the above characteristics (see Figure 3). The particular application, and the demands of the consumer are the principal driving force in lighting research.

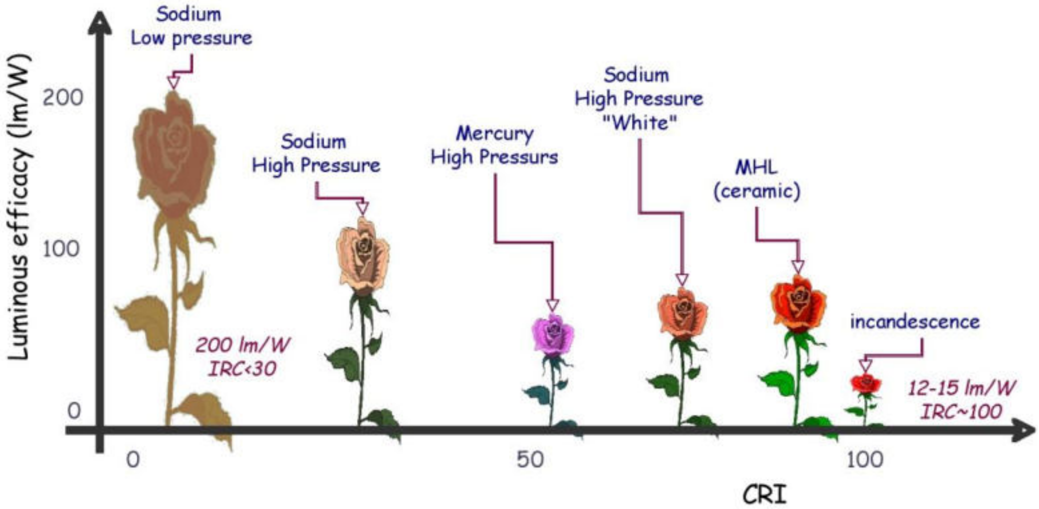

Figure 3 Rating of some electrical light sources according their CRI and luminous efficiency

3 THE IDEAL WHITE LIGHT SOURCE

It is possible to define the theoretical optimum light source in terms of maximum luminous efficacy at 100% radiant power efficiency for a "white" light source having good colour rendering capabilities. If one were to specify a blackbody-like spectral power distribution in the visible, with zero radiant emission at any other wavelength, then at 100% radiant power efficiency, the luminous efficacy is about 200 lm/W.

However, it proves to be possible to do better than that; radiation in the far red or far blue is not effectively utilised by the eye for either colour response or brightness response, although these extremes are customarily considered part of the visible spectral band. Acceptably good colour-rendering properties may be achieved in a light source, which is radiating in just three narrow wavelength bands: blue, green, and red. Most coloured objects have sufficiently broad reflectance spectra that they reflect light in two or more of these bands, and the eye-brain system accepts a colour definition dependent on the ratio of these two intensities of reflected light. Provided the wavelengths of the emission bands are chosen to be those corresponding to the maximum of the action spectra for the eye response to red, green, and blue, the brightness sensation perceived by the eye can be maximised simultaneously with the colour response. Light sources with such spectra can simultaneously have higher luminous efficacy than any continuous-spectrum source while maintaining nearly equivalent colour-rendering properties.

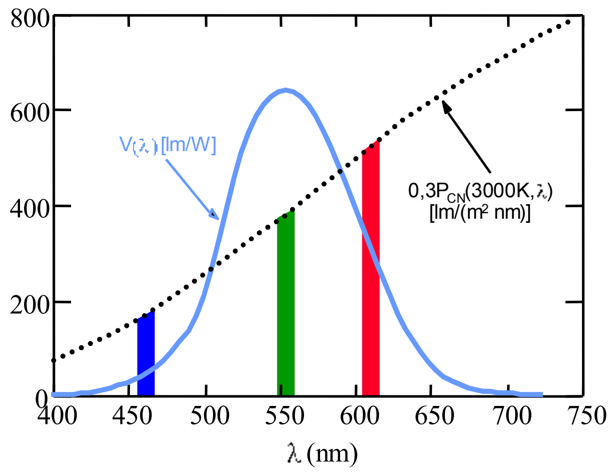

Figure 4 How calculate the maximum nominal efficiency of a white light source

For instance (see Figure 4), consider an ideal source radiating as a black body at 3,000 K the following narrow spectral lines: 450, 555, and 610 nm, the eye photopic response has the values of 51.5, 683, and 343 lm/W at the three wavelengths respectively. The resulting luminous efficiency is approximately 300 lm/W, with the apparent "colour" of the light being the same as that of a blackbody at 3000 K (this a realistic CCT value for white light), and colour rendering comparable to this blackbody emitter. This figure of 300 lm/W then represents the probable upper limit for luminous efficiency of a three-wavelength-emitting source having colour rendering acceptable for nearly all-lighting applications.

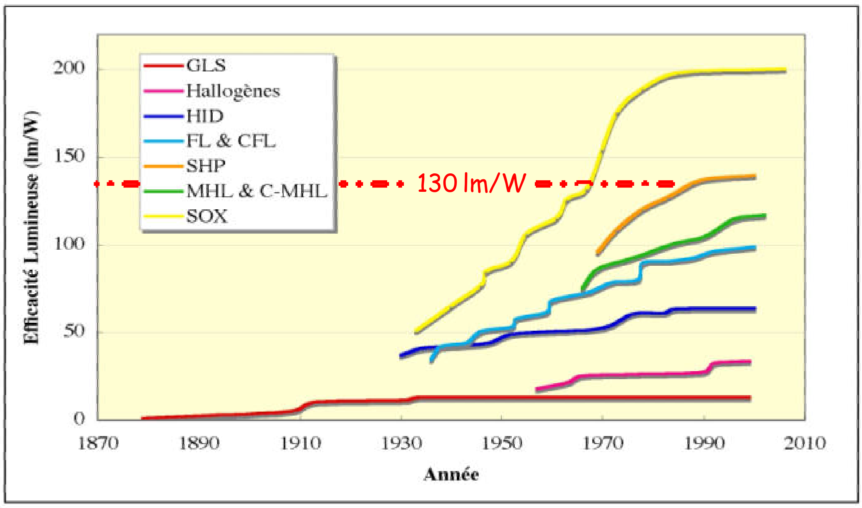

Figure 5 Evolution in the efficiency of some light source families (LEDs are not included in this graphics)

As shown in Figure 5, after increasing steadily throughout the previous seventy-five years, efficiency of conversion of electric energy into light by commercial light sources appears to have reached a plateau of about 33% of the theoretical maximum. No truly revolutionary new light sources have been introduced since the mid-1960's, marked by the debut of metal-halide and high pressure-sodium arc discharge lamps. Light source developments since then have been primarily evolutionary, with incremental improvements in efficiency. Overall system gains in lighting efficiency have in the last decade primarily resulted from the substitution of more efficient sources for less efficient ones (viz. compact fluorescent replacing incandescent). To achieve the continued load-saving challenges that will be required in the future, much greater efficiency improvements, of about a factor of two, will be required. Furthermore, from an environmental point of view a drastic reduction or elimination of harmful substances is required (viz. complete elimination of mercury).

The inability to develop dramatically improved light sources in recent decades has not resulted from lack of effort by the lamp manufacturers themselves. All of the major lamp manufacturers in the US and Europe have for many years maintained significant applied research and advanced development groups unburdened by day-to-day problem-solving responsibilities, but immersed in a highly-focused corporate climate. These groups have been, and continue to be, well aware of the limitations of existing lamps, materials and processes, and have been free to seek out better light-generating phenomena on which to base dramatically-improved products. If such phenomena were known at the present time then these groups would have explored them, modified them as necessary, and exploited them in commercial products. It seems, therefore that a fundamental reason for the present plateau in efficiency of light sources is that the industry has outrun the scientific base that has supported the technology since its inception: atomic physics and spectroscopy, and electron and plasma science, electronics and electrical engineering. Thus, the development of revolutionary new light sources having double the efficiency of current light sources can only be based on new scientific phenomena not previously considered for light source applications.

All the above discussion concerns the two main characteristics of the ideal white lamp, the luminous efficiency and CRI. Furthermore a "good" lamp should fulfil several other requirements. In fact a "good" lamp should:

1. have a high efficiency
2. have a high CRI
3. have a long life
4. produce a stable light level during its lifetime
5. avoid flickering
6. produce its nominal flux instantaneously when turned on
7. be exchangeable with other types of lamps
8. be compact and light
9. avoid harmonic distortion feedback to the electric network
10. avoid environmental harmful materials
11. avoid electromagnetic interference with any other electronic equipment
12. avoid excessive heat and UV rejection
13. be recyclable
14. be inexpensive

RECOMMENDED LITERATURE AND WEB LINKS

COST-529 action web: http://www.efficient-lighting.org/

Efficient Lighting Initiative: http://www.efficientlighting.net/

European GreenLight programme: http://www.eu-greenlight.org/

US lighting research office: http://www.epri.com/LRO/index.html

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- concept estetic nou
FLO, O NOUĂ FAMILIE DE STÂLPI ȘI BRAȚE PENTRU TOATE APLICAȚIILE DE ILUMINAT URBAN.
EnergoBit Schréder
Schréder Group GIE

Luxten este cel mai important producător român de corpuri de iluminat, contori, sisteme de telegestiune si control, echipamente pentru retele de infrastructura. Activitatea Luxten se desfasoara in două fabrici: la Bucureşti-specializată in iluminat şi Timişoara-specializată in contoare şi aparatură de măsură.

Astăzi, Luxten acoperă toată gama de servicii pentru sisteme de iluminat: audit, proiectare pe bază de program de calcul şi optimizări de soluţii, execuţie lucrări, soluţii la cheie pentru iluminatul stadioanelor, sălilor de sport, pasaje subterane, clădiri istorice şi administrative, monumente, grădini, parcuri si contorizam toate consumurile casnice: energie electrica, gaz, apa si caldura, intretinere-mentinere pentru lucrarile executate si este lider naţional în domeniul contoarelor şi aparatelor de măsură, singura companie producatoare din Romania care acoperă toată gama de produse de contorizare în domeniul utilităţilor (energie electrică şi termică, gaz, apă)si care a dezvoltat sisteme de gestiune si control pentru monitorizarea si managementul energiei electrice, ce permite extinderea si reconfigurarea conform cerintelor clientilor.

Luxten este administratorul serviciului de iluminat public al Capitalei in urma castigarii licitaţiei internaţionale organizate in noiembrie 1997 de Primăria Municipiului Bucureşt. Mai mult, Luxten gestionează şi consumul de energie electrică aferent iluminatului public din Bucureşti, aducând prin soluţiile oferite numeroase beneficii municipalităţii.

În prezent ne ocupam de modernizarea iluminatului public în peste 20 oraşe, avand in prezent in gestionare peste 200.000 de puncte luminoase printre care orasele: Bucuresti, Ploiesti, Alba Iulia, Constanta, Oradea, Craiova, Baia Mare, Galati, Braila, Roman, Medias, Vatra Dornei, Piatra Neamt, Deva, Hunedoara, Iasi.

Incepand cu anul 2000, inca de la deschiderea pietei, suntem furnizori de energie electrica iar din luna mai 2006 suntem producatori de energie electrica, prin achizitionarea unui numar de 7 microhidrocentrale de pe Valea Doftanei – CHEMP Tesila 1, CHEMP Tesila 2, CHEMP Traisteni 1, CHEMP Traisteni 2, CHEMP Negras 1, CHEMP Negras 2, CHEMP Prislop.

Toate activităţile din cadrul societăţii, de la marketing la proiectare, producţie şi vanzare se desfasoară in concordanţă cu exigenţele standardului ISO 9001. Implementarea şi menţinerea acestui sistem de management al calităţii au fost certificate de prestigiosul organism internaţional KEMA din Olanda încă din 1994 pentru fabrica din Bucureşti şi 1999 pentru cea din Timişoara.


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MOELLER ELECTRIC Romania – scurta prezentare

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Moeller Electric este specializata in comercializarea echipamentelor pentru automatizarea si distributia energiei. Moeller Electric are peste 60 de angajati, din care 35 ingineri tehnico-comerciali, scolarizati periodic la centrele de perfectionare din Germania si Austria. De la sediul central din Bucuresti sau de la birourile din Brasov, Baia Mare, Constanta, Craiova, Iasi, Cluj, Sibiu si Timisoara acestia sunt permanent la dispozitia clientilor, activitatea lor remarcandu-se prin profesionalismul si calitatea serviciilor oferite, fapt confirmat de lucrarile de referinta realizate.

Grupul Moeller este unul din liderii mondiali in productia de echipamente electrice pentru distributia energiei si automatizari. Compania are o retea eficienta de vanzari pe toate pietele relevante, fiind reprezentata in peste 90 de tari prin 29 de sucursale si peste 350 de birouri de vanzari, parteneri si distribuitori. Multumita structurii sale internationale de productie formata din 16 intreprinderi, Moeller este capabila sa utilizeze avantajul locatiilor regionale si sa se concentreze asupra oportunitatilor oferite de cresterea globala a pietelor. Grupul Moeller are in jur de 8.700 angajati (30 Aprilie 2006) si in anul financiar 2005/2006 a realizat vanzari consolidate de 890 milioane EUR.

Moeller Electric Romania ofera clientilor sai nu numai produse de exceptionala calitate ci si un pachet de servicii conexe, de care clientii pot benefia inca de la primul contact. Pachetul include, intre altele si consultanta tehnica sau asistenta in toate fazele unui proiect. Moeller Electric dispune de un stoc local important care permite livrarea rapida a produselor catre clienti.

Moeller ofera solutii moderne pentru distributia energiei, controlul si monitorizarea proceselor industriale, automatizari in cladiri. Aceste solutii se bazeaza pe aparatura de protectie si comutatie, sisteme de control, convertizoare de frecventa, automate programabile, tablouri electrice realizate in cadrul grupului. Produsele Moeller sunt utilizate in aplicatii variate precum instalatii si sisteme electrice destinate aplicatiilor industriale sau managementului cladirilor, in automatizari de masini -unelte si procese de productie. Printre noutatile lansate in ultimii ani se numara si sistemul Xcomfort, un sistem care permite controlul “wireless” al iluminatului, incalzirii, ventilatiei, etc. dintr-o locuinta.

Moeller Electric Romania a furnizat componente si/ sau tablouri de distributie pentru aplicatii precum:

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- Floreasca Tower - Bucuresti
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- Palatul Parlamentului, Raiffeisen Bank, Tribunalul Municipal Bucuresti
- Supermarketuri: Altex, Bricostore, Mobexpert, Praktiker, Kaufland, XXL.
- Hoteluri: Raddisson –Bucuresti, Novotel Bucuresti, IBIS Bucuresti, Europa din Eforie
- Coca Cola din Timisoara
- OMV-Petrom, Lukoil – Petrotel, Rompetrol – Petromidia,
- MittalSteel, ALRO Slatina,
- Carpatcement, Holcim, Lafarge
- Coficab Timisoara: fabrica de componente electrice pentru industria de automobile,

Str. PlevneiNr. 18, 400349 Cluj Napoca

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E-mail : office@pragmatic.ro; web: www.pragmatic.ro

Societatea Comercială PRAGMATIC COMPREST S.R.L. a fost fondată în 1994, ca răspuns la cerințele pieței de comercializare şi distribuție a produselor electrice din țară şi import. Obiectivul principal al firmei Pragmatic este să vină în întâmpinarea clienților săi cu cea mai completă ofertă de articole electrice. Pragmatic cunoaşte o continuă dezvoltare, astfel, în 1996 deschide primul magazin, iar mai târziu încă trei. În 1999 cumpără firma Cerasind, iar în 2001 achiziționează pachetul majoritar de acțiuni de la Cominex.

După 13 de la înființare, PRAGMATIC COMPREST are un capital de peste 3.000.000 lei, patru magazine, un sediu modern şi un număr de angajați de 130 de persoane din care majoritatea sunt tineri.

Societate a fost premiată pentru rezultatele obținute de către Camera de Comerț şi Industrie CCI Cluj cu locurile 2 şi 3, în anii 2005 şi 2006.

PRAGMATIC COMPREST comercializează întreaga gamă de produse şi echipamente electrice de joasă şi medie tensiune, aparate de iluminat, distribuție electrică, tablouri şi cofrete electrice, aparatj de conectare şi protecție. Principalii furnizori ai societății sunt: ELBA, ELECTROAPARATAJ, GEWISS ITALIA, HENSEL ROMÂNIA, PHILIPS ROMÂNIA, PHILIPS & ELBA STREET LIGHTING, SCHNEIDER ELECTRIC, MOELLER ROMÂNIA, KONTAKT SIMON POLONIA.






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- Lucrari de montaj
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CERTIFICARI

- Centru de service autorizat SIEMENS A.G.
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- RAVJ Petrosani- Statie suflante actionate cu convertizor Midimaster Vector 22 kW, statie epurare Danutoni, automatizare si alimentare cu energie electrica Statii de epurare si pompare Lupeni si Uricani
- HOLCIM Alesd: Modernizare Statia pompe apa Cris
- HOLCIM Ciment Turda: Automatizare si alimentare cu energie electrica “Statia de pompe apa industriala”
- DYTRAS- Reabilitarea statiei de alimentare cu apa potabila Tg. Mures

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- LAFARGE- Sistem de distributie energie electrica si compensare factor de putere, automatizare
- CARPATCEMENT Holding- lucari de automatizare si instalatii electrice

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- SANEX Cluj- Actionari mori, Refacere PT si compensare factor de putere, Automatizare cuptor si linie presaj
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