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The journal **INGINERIA ILUMINATULUI - Lighting Engineering** - is affiliated to the CNRI - Romanian National Committee on Illumination, member of the CIE - Commission Internationale de l’Eclairage. It has a scientific presentation and content, targeted to the continuing education in the lighting field.
The objectives of the journal consist of the presentation of the results of the lighting research activity, the dissemination of the lighting knowledge, the education of the interested people working in public administration, constructions, designers, dealers, engineers, students and others.
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LIGHTING QUALITY AND ENERGY EFFICIENCY, A CRITICAL REVIEW

Wout van BOMMEL

With regard of lighting quality and energy efficiency, the situation of today and possibilities in the future are very much dependent upon our quality as lighting professionals. The review is therefore structured around the four questions:

Question 1: Do we have the right focus in product development? In 1972 the Club of Rome, a small international group of professionals from the fields of diplomacy, industry, academia and civil society, produced its report "The limits to growth". This report showed, for the first time, the contradiction of unlimited growth in material consumption in a world of finite resources. The lighting world has learned to react quicker, especially also since in the nineties of the last century next to shortage of availability of resources, also the negative consequences of CO_2 emissions on climate change became apparent. Today ***sustainability*** is the key word. From a society point of view, sustainability and, in that context, energy friendly, long life product and application design will remain important.

* Intelligent installations optimize the use of the lighting, further decrease the energy use.

* The design of the total installation (lamps, luminaires, gear and layout of luminaires) is today geared towards energy friendly installations that live long.

* The lighting industry has to focus more on total waste free products. Recycling of glass, mercury and phosphors can be seen as an important but first step, if we take all lighting installation components into account.

* Futuristic daylight products like transparent OLED windows, transparent solar windows and translucent concrete, can increase the daylight use in interiors. The city of Stockholm has a demonstration project with translucent concrete in a sidewalk.

Question 2: Do we use the right basic information?

* The very small size of an individual LED is one of the very interesting properties of LEDS. It opens whole new possibilities to create light distributions that were with the larger conventional light sources not possible. However the same property gives in many applications the risk of glare. Good glare restriction in solid state lighting requires innovative optical designs. Here a totally new glare evaluation system is needed as the present systems have been developed for circumstances totally different from solid state lighting. It is needed to develop a whole new glare evaluation system. This would also give the chance to try to develop one generic system for all application fields.

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* In fixed road lighting, especially for motorway lighting, we base our concepts on visibility of objects but that concept looses importance because of developments in car systems themselves. The Advanced Front lighting System (AFS) is an intelligent and automatic car lighting systems. It has specific urban-, highway- and “curve” beams that reach far and even “around the corner”. They increase visibility of objects to such an extent that often sufficient visibility can be guaranteed by the advanced car lighting system alone. The role of fixed road lighting will move much more in the direction of providing traffic guidance, facilitating traffic flow, and probably towards an aspect that so far has received little attention, reducing micro sleeps.

* Neurological research is needed to find out if fixed road lighting can contribute to minimize micro sleeps in night drivers.

* For lighting in built-up areas, instead of the luminance concept of road lighting a more three-dimensional concept is needed. Here also the color contribution to identification of human faces with different lamp spectra should be evaluated.

Question 3: Do we provide the users with the right information?

* In conventional lighting the vast majority of suppliers of both products and lighting designs provide correct data about their products or designs. It is disturbing to see that this is too often not the standard procedure when it comes to solid state lighting. The changeover to solid state lighting may be slow downed because it is precisely for solid state lighting that often wrong data are supplied, thus disappointing new users in their expectations.

* Especially in the popular press we have seen quotes of laymen but sometimes also of authorities from the lighting or medical profession saying that domestic use of LED-lamps instead of incandescent lamps can disturb the biological clock and therefore also the natural body rhythm. The reasoning is that LED-lamps have a peak in the blue part of the spectrum for which the biological action spectrum peaks as well. In order to verify such statements we made detailed calculations for many different LED-lamps, a CFL lamp and a normal incandescent lamp. Statements that for domestic home lighting the changeover from incandescent lamps into LED-lamps gives a health risk are shown to be incorrect.

Question 4: Do we address the right public?

***** Most recommendations and standards on lighting quality are based on people of around 30 years old. With growing age, eyesight deteriorates. It is therefore essential that in lighting recommendations and standards special sections are going to be incorporated on the special needs of the elderly. It is shown that the efficacy of LED-lamps is negatively affected by the blue light loss of the aging eye. 1.6 billion people in developing countries have no access to electricity. It is good to see that where so far only non-profit organizations were offering low-cost solar home lighting units, larger lighting manufacturers are now developing off-grid concepts for remote rural areas.

This is a short version of the presentation at CIE Conference: "Lighting Quality and Energy Efficiency" March 14-17, 2010, Vienna, Austria; www.cie.co.at

AN ASSESSMENT OF MARKET LEDS LAMPS AS SOURCES FOR GENERAL LIGHTING

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Abstract. *A number of LEDs lamps commercially available were analyzed in the electric and photometric laboratory at the Department of Light and Vision of Universidad Nacional de Tucumán (Argentina). Evaluation were according to the criteria currently applied to assess conventional lamps, which include energy efficiency, life and survival, color quality, range of powers. Besides other aspects were also considered, such as those dealing with environmental and human health, some of them underlying in the documents IEC 60825-1, Safety of laser product and CIE DS 009 Photobiological Safety of Lamps and Lamp System. The conclusion is that in many respects LEDs lamps have revolutionized lighting, while others still remain far from fulfill the requirements to replace the classical sources, especially when high energy density is required.*

Keywords: *Photometry, lighting, energy efficiency, standards, assessment*.

1 LED market today

It is evident that LEDs lamps will play an important role among electric lamps. Specialists and designers are focusing their attention on this product, increasing the use of this technology in projects and applications. It is estimated that the market for the solid state illumination (or SSI as it is known), has grown at least a 30% annual rate in recent years, mainly based applications with LED lamps. The number of companies that offer is doubling every year and employ an increasingly proportion of ads in magazines.

At the present, LEDs have been used in a particular market segment, a niche, hardly served by conventional sources, providing two advantages over conventional lamps; miniaturization and color, especially when change and mixing tones are required. At the present the efficiency of LEDs producing color light is so high that can not be achieved by no one of conventional lamps (Table 1). For this reason LEDs are predominant for artistic, signalizing and traffic lights.

However, neither miniaturization nor color, but the higher efficiency, high CRI, and the longer life are the main aspects which could extend the use of LED lamps to general lighting applications. General lighting installations range from small indoor lighting to large open areas, and represent almost the 25% of the global electric energy use [14].

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Table 1 Efficacy of LEDs producing color light (in lumen-color per watt).

Color	Efficacy lm/W	
	Minimum	Maximum
Red intense	14	15
Red orange	26	45
Orange	18	22
Yellow amber	50	100
White	80	150
Yellow green	30	60
Green	50	80
Blue greenish	50	65
Blue intense	17	25

One limitation of the current LED technology is the low-powered of units available at the moment in the market, from 3 mW to 5 W, with a maximum light output of 90 lm per unit, which is too little for most lighting requirements. LED lamps manufacture is based on the assembly of a series of diodes in a single unit. Until it becomes possible for the industry to produce higher power LEDs, the technique of grouping multiple diodes in a single capsule, seems the only way to enable the use of this technology in general lighting. Some products are conformed of 1,600 units. Hence, the LED lamps can be considered as consisting of three parts: a power device, a number of LEDs and a container with a conventional cap (Edison, Goliath, Bay) resembling conventional sources. The other limitation is efficiency; performance below 50 lm/W only intended for replace GLS incandescent bulbs, are not acceptable, whenever at the present there are more efficient discharge lamps. Although LED performance of 150 lm/W and life of 50,000 has been announced [18] the products available in the market are far from this achievements.

2 The Turning Point

There is no doubt that once LED technology achieve a better performance at reasonably cost, as is expected, it use will become massive, encompassing any sort of applications,. The future looks promising; in the recent years LED performance, measured in terms of efficiency, color and luminous output, had a remarkable enhancement, and, what is even more important, it seems that this technology are still far from his maturity. In such case many or almost all kinds of the conventional lamps may eventually disappear, in the same way that incandescent lamps are disappearing by the increasing use the of the CFL's. How far we are now to the maturity of LED technology and how many years will need this technology to be adopted by the market? To answer this question, let us to compare the case of three well-known developments; tri-phosphor T8 fluorescent lamp, the high frequency electronic ballast and the compact fluorescent lamps.

As Table 2 suggests, market penetration of any technology of efficiency will depend not only on the maturity of the technology, but also of technical and non-technical barriers that arise.

Table 2 Three well known lighting technologies. Elapsed time to present market penetration. (Argentina)

Efficiency technology	Launched in	Addressed to replace	Present market share
Electronic ballast	1982	Standard magnetic ballast	3%
T8 triphosphor fluorescent lamp	1976	T12 fluorescent lamp	70%
Compact fluorescent lamp	1980	Incandescent	35%

Figure 1 Former and present technology in CFL lamps. Former lamp consisted in a mere banned fluorescent tube with conventional ballast.

Compact fluorescent lamps technology has similarities with LED lamps. CFL lamp was launched at the end of the 70s, 30 years ago. The first lamps CFL (Figure 1), sold at 30 $ per unit, were a bending fluorescent miniature tube coupled with magnetic ballast and a glow switch starter. Weighing more than 200 grams, and delaying nearly 2 minutes to reach its nominal light output, the adoption of such lamps in the market was at the begin, very limited. Much had to bring the technology to produce the current CFL lamp, with embedded electronic ballast, light and competitive price.

Furthermore, the adoption of CFL by consumers has been promoted by governmental and independent campaigns, which included in many cases monetary incentives [19].

As those tools have not been enough to achieve the massive use of CFL technology, many governments have adopted a policy of eliminate incandescent lamps of market [8]. This can be expected from LED bulbs, and a similar policy will be needed to push this technology into the market. Before, it is necessary to develop standards and test procedures to help, orientate and protect consumers.

3 Current market

- Domestic market are growing at an annual rate of 30% in Argentina, however, LEDs use in general lighting applications are still insignificant.
- The great market expectations for SSI, come from lighting designers and specialists.
- The few technical information on LED lamps, are mainly provided by manufacturer or suppliers and in many cases are unreliable.

A wide variety of products can be found today in the market. Products can be grouped according by their similar purposes:

- LEDs lamps as option for tungsten halogen
- LEDs lamps as option for Fluorescent tubular
- LEDs lamps as option for CFL or EFL
- LEDs lamps as option for HPV lamps; Sodium, Mercury

Table 3 Present LED market (Argentina)

Feature	Minimum	Maximum
Number of LED per unit (Nr.)	1 (high power LED: 3, 5,10 W)	1600 (street lighting luminaire)
Power range (W)	0,25 (SMS LED-HB class III)	400 (street lighting AP 1001)
Life range (h)	20,000	70,000
Light output range (lm)	50	14,000 (street lighting AP 1001)
Efficiency range (lm/W)	46.6 (3x0.5 W/70 lm)	81.25 (20 W/1600 lm)
Price range (€)	3.6	650

3.1 Products range

According to commercial information, LEDs lamps have achieved a performance, in terms of duration and efficiency, comparable to those of discharge lamps (Table 3)

4 Evaluation Criteria

LED lamps should be evaluated in the same extent and in the same parameters that conventional lamps are evaluated, mainly:

- Lumen efficiency
- Lumen depreciation
- Life and Endurance
- Color quality and color shift
- Intensity distribution
- Environment impact

The first difficulty on LEDs evaluation is the lack of reliable test methods and, consequently, lack of independent assessment. An Independent certification is needed to find out whether available LED lamps meet the performance that is expected of them. Low quality LEDs could result in future loss of consumer confidence, and this loss of confidence will be difficult to reverse in the future, as occurred with other technologies such as electronic ballasts. Electronic ballasts for tubular fluorescent lamp market were launched at the beginning of the decade of the 80s. The first products on the market were of poor quality and experienced early failures. As result, the market lost the confidence in this technology. Today, although there are standards and procedures for product certification, the distrust on electronic ballasts are still alive and consequently the use of them is low compared with other nations.

5 Laboratory tests

Two type of multiple LEDs lamp and two spot LED lamps were tested according to our own criteria, mainly those applicable to conventional lamps. One of the two spot lamp were a multiple diode lamp (D1), and the other a single-high power LED one (P1). The other lamp type (V1) was a general lighting lamp (opal) - Figure 2a and 2b.

Figure 2a

Figure 2b

Table 4

Efficiency range of LEDs lamps according to commercial information	Minimum	Maximum
	46,6 lm/W (3x0,5 W/70 lm)	81,25 lm/W (20 W/1600 lm)

5.1 Lumen efficiency and depreciation
According to commercial information, LED efficiency ranges from 46 to 81 lm/W (Table 4). However, this figure can not be confirmed by laboratory tests (Figure 3).

5.2 Efficiency depends of voltage
Variation ranges from -1% /2 Volt to -1%/5 Volt (Figures 3 and 4)

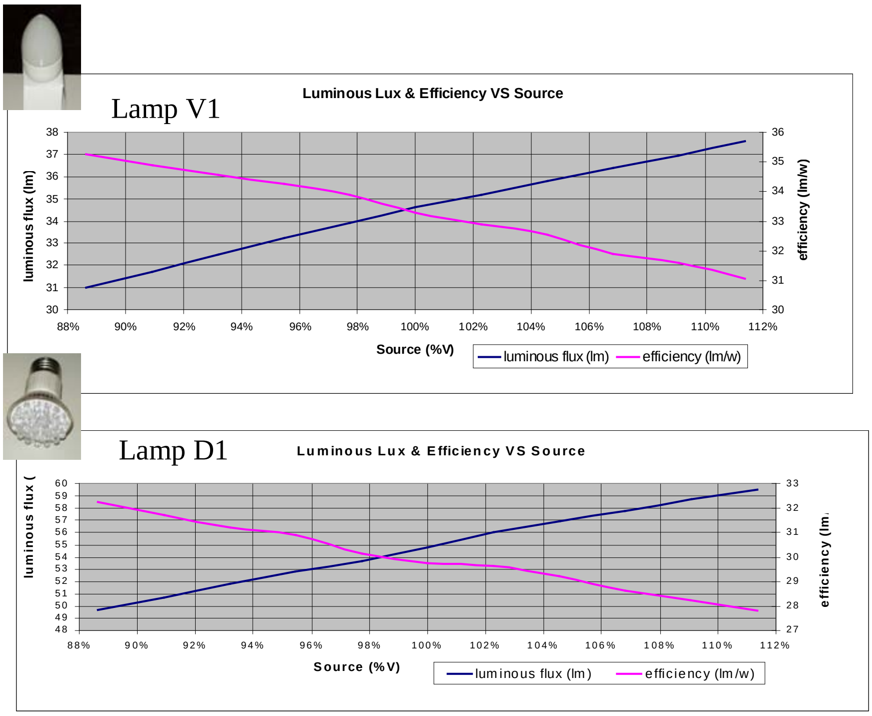

Figure 3 Dependence of luminous flux and efficiency with source voltage. Múltiple LEDs lamps (V1 and D1).

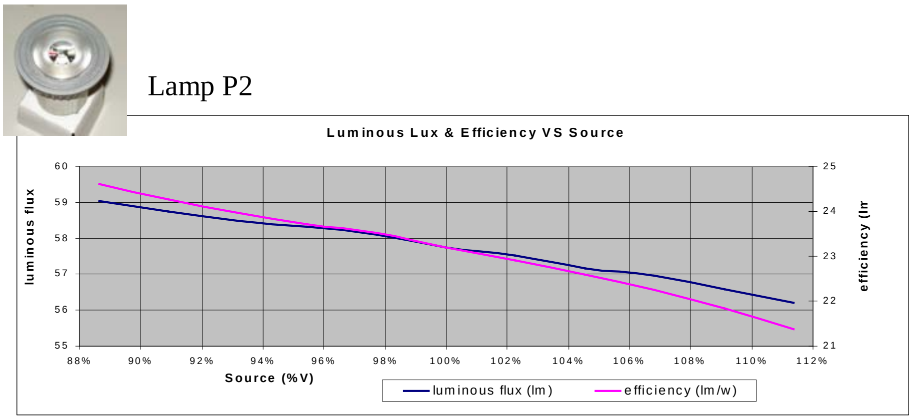

Figure 4 Dependence of luminous flux and efficiency with source voltage. Single LED lamp (P2).

5.3 Efficiency drops with temperature

The dependence of LED output with temperature is well known [13, 16]. Variation, according to the present tests, ranges from -7%/ºC to -0,25%/ºC (Figure 4).

Removing of heat seems to be present limitation to higher power densities. Heat affect both: lighting output and life.

- A simple LED unit only account low power. To get higher output, a number a LEDs are assembled in a board (LED array). Some luminaires account 1600 units.
- Advanced LEDs are encapsulated with their own heat-sinks
- LED array may require better heat dissipation: the higher the numbers of unit in the array, the higher temperature and lower lumen output are.

LED array law: An isolated LED are more efficient than in an array. On the contrary: Conventional lamps increase efficiency with higher power.

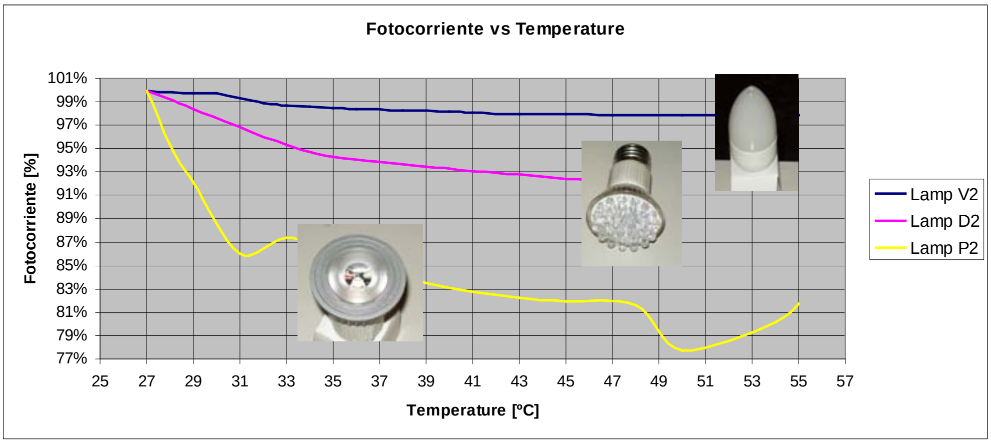

Figure 4 Luminous output versus temperature.

5.4 LED life and endurance

- One promising aspects of LEDs is their expected long life, estimated from 20,000 to 70,000 hours.
- Procedures for life evaluation seem to be a critical aspect. At the present there is not any accepted procedure to asses LED life. However there are some proposals on tests.
- As most conventional lamps, the life of the LED is not affected by frequent switch cycles. On the contrary, high temperature and overvoltage may affect performance and reduce life.

5.5 Useful life criterion

- Luminous depreciation is critical in LED life. As in the case of conventional lamps, depreciation of 50% (or 30% in some cases) of their luminous output may determining the useful life of LEDs lamps. The same criterion may be applicable for color shift.

- Based on this concept ASSIST (Alliance for Solid-State Illumination System and Technologies - Lighting Research Center – Rensselaer) proposes a 6,000 hours (10 month) test to assess lumen depreciation and color shift. Useful life is obtained by the extrapolation on depreciation [2-8].
- In our opinion lumen depreciation is not the only factor to determine LED life; endurance also account.

5.6 Endurance criterion

- LED are sensitive to grid-transients. Over voltages/current may accelerate lighting depreciation or result in early failures.
- A test under abnormal conditions, those commons of power supply is currently being developed to proof LED endurance

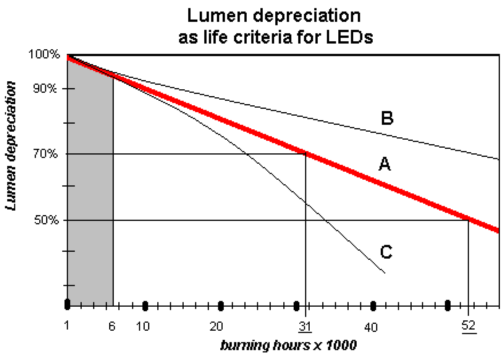

Figure 5 The lumen depreciation criteria proposed by ASSIST to estimate LED life, which consider a linear depreciation for LEDs (A), may result over-predictor or sub-predictor for depreciation like (C) or (B)

6 Environmental aspects

Concerning the impact on the environment of LED lamps, two main issues should be consider:

- LED lamps manufacturing implies less material and critical substances than any other conventional lamps, therefore they impact less on the environment. This situation will become largely favorable after technology produce LEDs with high life and efficiency that is expected.
- Does LED light cause damages to human health? Although LED emits non-coherent radiation, further studies are carried on to ensure that in any circumstances LED light are not harmful to humans. Two aspects has been considered, one, the inconsistence between IEC and CIE standard on LED, and other, the high BLH contents of LED lamps.

6.1 Inconsistence between IEC and CIE standards

There is an inconsistence between standards of the CIE (CIE DS009) and IEC (IEC 60825-1) on the assessment of risks from exposure to LED light (Table 5). IEC is more strict and consider LEDs as laser sources. Whatever the reason for the IEC to consider the LEDs and lasers is something that should be carefully analyzed [17]

Table 5

Aspects	**IEC Standard** [15]	**CIE Standard** [10]
Classification	LED is considered as a laser	LED is considered as a lamp for general service
Definitions for source geometry	Smallest image in retina containing 63% of total power	Emission of 50% of source output
Pupil diameter to assess hazards	7 mm	3 mm
Distance of the source	100 mm	200 mm

6.2 High contents of BLH in LED lamps

Available LED lamps have much higher contents of BLH (Blue Light Hazards) compared to conventional lamps. BLH is a non-thermal photochemical retinal damage and has an action spectrum (E_B) within the visible range, with a maximum response on the blue region of visual spectrum [9]. Although BLH is associated with high intensity or long term retinal exposure, there are special circumstances that can lead to higher risk, for example, patients with reduced mobility in a hospital.

7 Conclusions

- According to laboratory evaluation, LEDs lamps available on the market have an average lumen efficiency less than 30 lm/W, far from commercial information.
- At the present stage of the technology LED may be a good option to replace tungsten halogen spotlights. However, the LEDs performance is still bellow of the CFL and other discharge lamps.
- The development of appropriate measurement protocols and test procedures will help LED technology to get its maturity. Independent third party assessment and certification according standard, will shorten the adoption of LED lamps into the market. On the contrary, lack of standard and lack of independent evaluation can distrust confidence of consumers on LED products as it was the case of electronic ballasts (HFEB).
- Appropriate research and evaluations have to be done to ensure that in any circumstances LED light cause damages to human health [18].

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POINT OF VIEW: QUALITY IN LIGHTING EDUCATION

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Abstract. *The professional certification in lighting is a recent action of CNRI (Romanian National Lighting Committee), based on the fact that a general curricula don't generate automatically an acceptable qualification. This research relies on the methodology of development of the national superior education qualification (a project of the national agency – ACPART). According to the EC, this activity has already reached the frontiers of knowledge. The presented approach is even more ambitious, as it anticipates some of the demands of the national qualification background for superior education (in progress). The originality of this paper resides in the fact that it is in search of an instrument of objective evaluation of lighting specialists. The elaboration of the National Register of the Superior Education Qualifications (CNCIS) requires a long-term effort, which is ACPART's mission. What is required is a methodology of competences assessment at the end of each of the education stages: licence and master. This is the area where the assessment will reach a new level, by looking for an approach, which makes the difference between the classic evaluation, and the pragmatic evaluation of the employer, on the other. Until then, this is the CNRI mission, in connection with professional association of electrical engineers (SIEAR) to demonstrate the tradition in lighting education at Technical University "Gh.Asachi" of Iaşi, a short history is presented, until these days.*

Keywords: *qualification, evaluation of lighting specialists, history in lighting education*

1 Introduction

Starting from the premise that continuous studying and formation has become a necessity in Europe, that the barriers among countries not only prevent the access to educational and vocational formation, but also restrict the efficient use of knowledge and competences already possessed by individuals, the boards from the field of European educational policies asked for the elaboration and implementation of a **European Qualifications Background** [1], seen as some sort of meta-frame, the main goal of which is to consolidate the links between the staffs on a national and sector level, to facilitate and promote the transparency, the transfer and the acknowledgement of qualifications and competences on an European level. One of the directions of the European Commission's policies is the reformation of superior education institutions, so that they become more flexible, more coherent and more open-minded to the needs of the society, and thus capable to answer to the challenge of globalisation and to the needs of formation and re-formation of the European workforce. The reforms on this level should prepare universities to assume their role in a Europe of knowledge and to bring a more firm contribution to the attaining of the goals established by the European Commission through the Lisbon Strategy.

2 Competence assessment in lighting

By taking into account the peculiarities found on an European level, the Commission suggests that the following transformations would represent the way to the success [2]:
the breaking of the geographical and intersectorial borders that separate the European universities;

- the guarantee of the real autonomy and responsibility of each university;
- the development of partnership among universities, the business community, financial and local communities spokesmen;
- the guarantee of the demanded competences on the work market;
- the reduction of financial deficits and the finding of a way to make more efficient the activities in
- the fields of education and research;
- the augmentation of the number of programs of inter-disciplinary and trans-disciplinary studies;
- the reward of the highest level of excellence;
- the increase of transparency and attractiveness of the European Superior Education field.

The development of the Frame for Qualification in the Field of Superior Education (CNCIS) provides answers for a European need of access and progress in a university career, but regarding also the mobility of students and graduates. At the same time, it expresses a new perspective, more concentrated on the students, in agreement with the present international context. As a conclusion, in order to become a reliable mechanism of internal and external regulation in the field of superior education, this complex system, the CNCIS, should be intelligible for all the interested groups. To the external arguments, stated on an European level, one can also add those which can be identified on a national level, like: the absence of a coherent structure of organising and classifying the qualifications, a system of university formation that is rather narrow-minded as reported to the financial and social environment, as well as a weak balance between the demand and offer of education and formation.

All the stated arguments show the necessity of developing of the CNCIS and of assuming of responsibilities by the institutions involved in making decisions in the field of Educational Policy, these institutions being directly interested by the principles and mechanisms of development and implementation of CNCIS, and also by the effects that the CNCIS generates on a national and European level. A common point of view on the initial approach and further development of the CNCIS is essential. One of the expected results of the process of realisation of the CNCIS is the use of qualifications, expressed in terms of results of studying. Two fundamental elements for the attaining of this objective are the active participation of all the relevant and interested categories, as well as their desire to take active part in the subsequent process of the curricular re-formation. The qualifications description is realised by the competences, because these are the main criteria for the employer. But CNCIS is to general and no details about lighting competences are indicated, until now. This is the perspective that assessment must be reconsidered.

3 The strategic actor: ACPART

As a national authority in the field, The National Agency for the Qualifications in the Field of Superior Education and Partnership with the Financial and Social Environment (ACPART) organises the frame of qualifications in partnership with the educational institutions and with the financial and social partners [3], by:

- the elaboration, implementation, updating and monitoring of the CNCIS, which will permit a broader acknowledgement of the results of the study, expressed in terms of *knowledge, abilities and competences*;
- the guarantee of the transparency of the CNCIS on a national and international level;

We can go even further, as we anticipate certain needs that will only arise after the creation of the National Board for Qualifications in the field of Superior Knowledge. This is the bench-mark that defines this exploratory research, the goal of which is to solve complex problems that can only be looked at from an inter-disciplinary point of view (the field of engineering and the educational sciences). The originality resides in the fact that we are in **search of an instrument of objective assessment**. This demand may seem rather far from realisation, mostly because the establishing of the National Register of Qualifications in the field of Superior Education in Lighting requires a long-term and sustained effort. But the procedure of university qualification validation (ACPART, annex 5, sheet 7: The Qualification Referential) already mentions that, besides the qualification curriculum and the inter-disciplinary sheet, the methodology of evaluation of competences and knowledge are also imperative to be specified at the end of the studies.

4 The applied units of competence

This is the area where we intend to revolutionize the assessment, by looking for an approach which makes the difference between the classic evaluation, influenced by all *the tolerated deviances* [4], on one hand, and the pragmatic assessment of the employer, on the other. This new vision, which comes in contradiction to the traditional point of view that “teachers know how to evaluate the best”, will draw the universities nearer to the business area and to the employers, a priority that can be this way fulfilled. The regulation of such an evaluation instrument is extremely difficult to realise, mostly because of the negative reactions of both teachers and students. One of the assessment instruments of **applied units of competence** will allow a more thorough knowledge of the truth regarding the results of learning [5]. This aspect is important on an individual level (*How competent have I become?*), but also from the point of view of the organisations whom are either preparing, or looking for specialists. As for the European opening of this instrument, it will allow us to have a broader view on the competence phenomenon on a European scale. What can be more motivating for a graduate than to be able to compare him with specialists all over the world?

If the role of the traditional subjective evaluation decreases, man will become a competitor willing to self-surpass himself. This is how this paper intends to bring a qualitative chance, the student being thus able to place himself on a multi-annual, European even, scale of competences he has gained. This way, the educator's value will increase too, because he will be seen as the main generator of plus-value for society. The traditional teacher-student relationship will become a real co-operation for every student to achieve competences in accord with his own professional development. As soon as the objective evaluation instrument will be regulated at a quota imposed by the employer, the relationship between the universities and the business climate will change considerably. The employers will give up the stereotypical phrase: *"Give me graduates so that I prepare them for the job I need"*. The universities will be able to enter periodical evaluation mechanisms of continuous learning, being thus able to certificate the progresses of the individuals engaged in formal or informal learning processes.

The main goal is the creation of such an evaluation instrument depart form the applied units of competence, on different types of jobs. A process of re-formation of the curriculum can already be noticed nowadays. The goal of this research is to create for each applied unit of competence a set of procedures to test the attained level. Of course, this means a different assessment, more detailed, of the knowledge obtained so far [6]. What is more important is that this instrument needs time to become credible, because it is necessary not only to create and validate the evaluation instrument (which will function on the basis of problems and situations simulation in a specific evaluation software), but also to organise a system of description of the competences not from the teachers' point of view, but from the point of view of the business specialists, who prove their competences on a daily basis. This is the most difficult approach, but at the same time it is the only one able to make this assessment instrument credible. By testing specialists already occupying different functions, the actual degree of the acquired competences will become clear.

5 The assesment of a fuzzy process

Both educators and students will be able to evaluate their performance in a detailed way and to give answers to questions like: *"Which is the degree of qualification of a specialist who wants to work in a certain field of activity, after graduating a university stage?"*

We want to measure something fuzzy. Competence is something witch belongs to the experienced specialists? No, it must be fixt this believes. Now, the professors but also the students will be able to measure the level of the competence after licence or master study, for a specific occupation and role.

The pioneer's work consists in the intervention in the purpose to improve the quality of the educational process in engineering. We have good information about different evaluation procedure at universities. We well know some procedures that impose a normal distribution (Gauss) for the results. But even there, the results are not good, because the financing system (based on number of students) impose the ignorance like a standard. It is sufficiently to be not the last, and the graduation is guarantied. We have a superficial evaluation system, time consuming, and with no resolution at all. In this point the proposed work will make the differences. The assessment will function based on PC network, and with special software. Based on this laboratory, each student will solve specialised problems to reveal the level of the competence (not only knowledge!).

It is important to emphasise this: it is a difference to evaluate knowledge and it is more difficult to describe and to evaluate competence!

After the hardware support, a huge database is necessary to be realised. This database will contain problems, learning objectives, algorithms and all that is necessary to generate in random way and off course with no human intervention, the specific tests.

6 The methodology

The assessment has to provide firstly an obligatory answer: *What measure unit shall we use?* The elitist approach of teachers would be depressive for every specialist, because it reflects the educators' bent towards perfection. In employers' world, the perspective is different and more pragmatic.

After the elaboration of specific methods of testing, evidently based on computer technique (simulation, modelling, problems analysis, evaluation tests), will follow the interpretation of the results that will be correlated with the perception of the business environment towards the meanings of competences. The key element will be time, the surveillance of the graduates after their free evolution in the profession.

It is through repeated testing that statistical and personal evolution will be revealed. The efficiency of reduced preparation cycles will be revealed through demonstration, while the personal development of certain individuals will be demonstrated as a measure of the competences acquired throughout one's life.

7 **Brief history of the electric lighting in the university of electrical engineering of Iasi**

Through the efforts of the Professor Dragomir Hurmuzescu, the Industrial Electricity School was born in 1910 as part of the University of Iaşi, than transformed in Electrical Engineering Institute, being the first academic school in the electrical field from Romania Studying the Annual of the University of Iaşi [7] it can be seen that between 1913 – 1916, through the foreseen disciplines was „Industrial physics and accumulators. Electric traction and Lighting" who's titular was Lecturer eng. N. Patriciu.

Undertaking a soviet model, the Electrical Engineering University had in 1951-1955 a single specialization called "The electrification of the industry, agriculture and transportation". The curriculum foresaw in the forth year of study a course of "Electrical Lighting" that was doubled by a project with the theme "Interior electrical lighting of houses and institutions". From 1948, another course kept in the university was the one entitled "Electrical lamps and luminaries". For these both mentioned courses, the titular was Professor Vasile Prisăcaru, which was in that time a personality of the electrical engineering in general and of the electrical lighting in particular and that worth some words of evocation.

Professor Vasile Prisăcaru was born in 1913 and starting with his last year of academic studies he was appointed, at 1st January 1942, as a trustee in the polytechnic school. He received his Ph.D. in 1965, and starting with 1967 he was appointed full professor with the Department of Electrical Energy Utilizations and Automation. He thought in a wide and a various fan of courses, not only the ones of lighting that were the most beloved. He received the Education Ministry Award in 1962 for the paper entitled „Experimental considerations on the dynamic auto modulation phenomena in the modulator-type magnetic amplifiers”. The article „Lamps power determination for the lighting panels with circular-disk shapes” published in the Romanian review Electrotehnica nr. 12/1959 was quoted in the Italian review L’Ellectrotecnica in February 1965 and in the volume „New achievements in the electric lighting” Technical Documentation Institute of Bucureşti in 1961. In 1966 he was appointed scientific doctoral coordinator in the discipline „Utilizations of Electrical Energy”, fact that allowed to several former young Ph.D. students in the decades ‘70s and ‘80s to sustain their thesis having the guidance of Professor Vasile Prisăcaru and to become at their turn professors in the Gheorghe Asachi Technical University of Iaşi. The Ph.D. thesis on the lighting field coordinated by Professor Vasile Prisăcaru are:

1. Contributions to lighting calculation using the electronic computers, eng. O. Stavrescu, 1974
2. Considerations regarding the photometric calculation of the lighting installations using models, eng. Claudia Botez, 1979
3. Contributions regarding the architectural lighting of the historical monuments, author eng. Iosif Gulacsi, 1985 – with application to Sf. Nicolae Church from Brasov.

The professor’s love for lighting have been manifested in various series of popularization lectures, but also in the several research contracts from that we mention: „DC supply of the emergency lighting in the electrical power stations” beneficiary ICEMENERG Bucureşti - 1969, „Public lighting optimization” beneficiary ICEMENERG Bucureşti – 1972, or „Lighting of the Bucureşti metro” ICSPM Bucureşti – 1976.

One of the followers of Professor Vasile Prisăcaru in the Faculty of Electrical Engineering of Iaşi was Professor Lorin Cantemir. He became in 1960 Vasile Prisăcaru assistant. The moment’s priority was to assure a proper material support for the applications. After some consultations with expert colleagues from Cluj (Dan Comşa) and Timişoara (V. Vazdăuțeanu), a number of 12 works laboratory were conceived and realized. We can mention the followings:

- Demonstrative panels with different fluorescent tubes;
- Automatic installation for the emergency lighting connection;
- Determination of the potential gradient along with the positive column to the fluorescent lamps;
- The study of the materials for the electric lighting sources;
- Operating - diagram tracing for the

fluorescent lamps in different montages;

- Curve-plotting of the lighting intensity distribution for different luminaries;

After years, Professor Lorin Cantemir led two theses in the electrical lighting field as Ph.D. mentor:

A. Study of electrical and photometrical parameters of fluorescent lamps by optimising power supply. author eng. Dan Ioachim, 1998

This thesis offered the possibility to apply and gain two Romanian patents, as follows: RO 77070/1981 entitled „Device for the power supply of the low-pressure fluorescent lamps”, authors D. Ioachim, M. Diaconescu and D. Jemna, respectively RO 89843/1977 entitled „Starter for the ignition of the low-pressure fluorescent lamps”, author D. Ioachim.

B. Contributions regarding the architectural lighting, author eng. Paul Chirilă, 2005

In that thesis, a new concept called „dynamic architectural lighting” was introduced and also was obtained the Romanian patent RO 120864/2007 entitled „Method and installation for dynamic architectural lighting”, authors: L.Cantemir and P.Chirilă.

After Professor Vasile Prisăcaru retired, the ones who teaches in 1975–1997 Electrical Lighting, were Professors Mircea Oprişor and Dan Ioachim. They edited the following manuals:

- Ioachim, M. Oprişor – Electric lighting and industrial electric installations, Iaşi – 1987 Rotaprint
- Ioachim – Design of the industrial electrical installations, Iaşi - 1991 Rotaprint
- Ioachim - Design of the industrial electrical installations – Design reference book, vol. I şi II, Iaşi – 1991 Rotaprint

The ”Electrical Lighting and Electrical Installations” Laboratory has a room of 72 m^2 (Figure 1). The

Figure 1 Electrical Lighting Laboratory

main laboratory works in the electrical lighting filed:

I. Stand of the low-pressure fluorescent lamps montages;

II. Panoply of light sources: usual (normal) incandescent and halogens lamps, fluorescent lamps (both usual and economic), supplied by electromagnetic or electronic ballasts, high intensity discharge lamps (sodium vapours, metallic halides, mercury vapours);

III. Photometric curves-plotting device for the light sources;

IV. Photometric characteristics' study and analysis of the lighting sources;

V. Stand for operating characteristic determination of the lighting sources (usual and halogen incandescent lamps, fluorescent lamps with inductive or capacitive ballast montage);

VI. Microprocessor-driven electronic ballast – Metrolight – of 250 W for HID lamps, with dimming possibility

Through the laboratory equipments we can mention: Analogical luxmeter Metro Blansko PU150; Digital luxmeter Mavoluxe 5032CIB USB – Gossen; Infrared thermometer with laser indication point ; Thermometer VT200 warm wired Kimo Constructer ; Three phase energy analyzer CA 8334 Chauvin Annoux.

In this effort we had a good model in The Lighting Engineering Center - LEC, established at Technical University of Cluj by Professor Florin Pop and his colleagues [8].

8 Conclusions

The preparing of the National Registry of the Qualifications in Superior Education is thus in work, necessitating a concentrated and long-time effort. Or, in the frame of the validation procedures of one university qualification (ACPART, annexe 5), is signalling (index 7: Qualification referential), that beside to qualification curricula and disciplines slips, must be specified the assessment methods of the competences at the finalization of the studies. This foresight guarantees that some of principles discussed in this paper will be quickly implemented in many universities, as long as the proposed instrument will be operational proved.

Some resistance to the change is possible. The depth which assessment takes gives the change. The final assessment, after one studies cycle, is changed from one simple ceremony without meaning (is not the place to demonstrate this affirmations, but the author assumes it) to a real measurement process. The measure means knowledge, and the knowledge is only the decrease of the incertitude degree. Unfortunately, the performances observed by educators are so weak in the last years, which the reaction of the educators may be one of to reject of this real evaluation necessity. But, in a perspective of five years, the things will change because the interaction of the educated – educator has the chance to orientate toward the formation of the real competences, and not auto-suggested. In present, the education is reported to a relative level (which is in continuous decrease), when we propose a referential objective for what should mean the competence. For the lighting education, we demonstrate that the problems are more difficult, because we need to find and to defend a place witch is indefinite, but also is assumed arbitrarily.

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LIGHTING EFFICIENCY AND LED LIGHTING APPLICATIONS IN INDUSTRIALIZED AND DEVELOPING COUNTRIES

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Abstract. *With the increase in the price of energy and with the public becoming more conscious of energy and environmental issues, more attention is being given for energy-efficient lighting. The design of energy-efficient lighting includes the use of efficient light sources, luminaires, control systems and also interior design with proper surface materials and placement of work places in relation to windows and luminaires. LEDs (Light Emitting Diodes) are new alternative light sources, which are foreseen to revolutionise the lighting technology in the near future. Electrical networks in most of the developing countries are limited mainly to the urban areas and therefore more than one-quarter of world's population uses liquid fuel to provide lighting. Increasing luminous efficacy, long life-time, and low power requirements make LEDs suitable to be used for lighting applications in industrialized and developing countries. Cost analysis of LED based lighting systems driven with renewable energy sources in different parts of developing countries have shown them to be cost effective in comparison with the existing options.*

Keywords: *LEDs light sources, lighting in developing countries, Annex 45*

1 Introduction

An energy strategy for Europe is aiming to balance sustainable development, competitiveness and security of supply. The proposed EU Energy Policy Targets and Objectives are: to reduce greenhouse gas emissions of developed countries by 30% by 2020; the EU has already committed to cutting its own emissions by at least 20% and would increase this reduction under a satisfactory global agreement, to improve energy efficiency by 20% by 2020, to raise the share of renewable energy to 20% by 2020 and, to increase the level of biofuels in transport fuel to 10%.

Lighting is a large and rapidly growing source of energy demand and greenhouse gas emissions. In 2005 grid-based electric lighting consumtion 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 megalumenhours/ person. In addition, each year 55 billion litres of gasoline and diesel are used to operate vehicle lights. More than one-quarter of world's population uses liquid fuel (kerosene) to provide lighting. [1] 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 applications. For the industrial-

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ized 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 lighting energy would limit the rate of increase of electric power consumption, 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. Important factors for lighting today are energy savings, daylight use, individual control of light, quality of light, emissions during life cycle and total costs.

2 Lighting energy and efficiency

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 estimated 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 Zealand, 58 lm/W in China, 43 lm/W in Former Soviet Union and 43 lm/W in the rest of the world. 35,5% and 39,5% of the light is still provided by the inefficient T12 and T8 fluorescent lamps, respectively. [1]

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 [5]. The use of LED based lighting could decrease the lighting energy consumption by 50% by 2025 [6]. 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.

3 IEA ECBCS Annex 45 Energy efficient electric lighting for buildings

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 Conservtion in Buildings and Community Systems (ECBCS). The function of ECBCS is to undertake research and provide an international focus for building energy efficiency. Tasks are undertaken through a series of Annexes that are directed at energy saving technologies and activities that support their application in practice. The findings are also used in the formulation of energy conservation policies and standards.

One of the Annexes of ECBCS is Annex 45 Energy Efficient Electric Lighting for Buildings. The goal of the Annex 45 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 of the Annex 45 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 the 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.

The main deliverable of the Annex 45 will be the guidebook on energy-efficient lighting. The guidebook is targeted for lighting designers, electrical building services and system integrators in buildings and the end-users/owners. It will include lighting electricity statistics in buildings, lighting quality criteria, energy codes and description of lighting technologies and control systems. It will also present commissioning process for lighting (control) systems and case studies. Also, technical potential for energy efficient lighting and savings are considered and proposals to upgrade recommendations and codes are given.

4 Lighting in developing countries

After Edison's futuristic statement over 100 years ago –"We will make electricity so cheap that only the rich will burn candles"[7] – the wishful dream of cheap, abundant electricity has not come true for more than 1.6 billion people around the globe, more people than the entire world's population in Edison's time. Only about 24% of the people living in sub-Saharan Africa had access to electricity in 2000 [8]. Electrical networks in most of the developing countries are limited mainly to the urban areas. In the rural areas of sub-Saharan countries, only 2% - 5% of the population is supplied with electrical networks. The grid connectivity is somewhat higher in countries such as Brazil, Bangladesh, India, Morocco, and South Africa, with 20% - 30% of rural population having access to electrical networks [9]. Rest of the people, who do not have access to the electric supply, use biomass and petroleum fuels for lighting. Fuel based lighting is not only inefficient and expensive compared to electric lighting, but is also a severe cause of respiratory and cardiac health problems. IEA [1] estimates that the annual energy consumed in fuel based lighting is equivalent to 65.6 Mtoe (Million Tons of Oil Equivalent) of final energy use. The estimated amount of global primary energy used for lighting is 650

Mtoe. The fuel based light sources include candles, oil lamps, ordinary kerosene lamps, pressurized kerosene lamps, biogas lamps, propane lamps, and resin soaked twigs as used in remote Nepali villages [10]. The ordinary wick-based kerosene lamps are the most widely used sources as fuel-based lighting in developing countries. For example, nearly 80 million people in India alone light their houses using kerosene as the primary lighting media [11].

The electrification rate in the developing countries has been continuously increasing during the past few decades. The urban electrification rate is higher than the rural one. The world urban electrification rate was estimated to be 91.2%, while the rural was 56.9% in 2000. Although the electrification rate is increasing, the number of households without electricity is also growing due to the population growth. Between 1970 and 1990, 18 million people in sub-Saharan Africa were newly supplied with electricity, but the total population growth at the same time was 118 million [12]. Similarly in South Asia, due to high population growth, the number of people without electricity grew by more than 100 million during the same period. Extending the electricity networks to rural areas of developing countries is very expensive due to the geographical remoteness, lack of basic infrastructures, and low population density. Hence, the remote and rural parts of the many developing countries are not expected to be accessed by electric networks in near future.

The use of renewable energy systems to produce electricity is becoming a viable option in fulfilling the basic energy needs of rural villages. There are a range of innovative and sustainable technology solutions which can meet the energy needs in developing countries [13]-[15]. The technologies involving wind power, solar power, and small-scale hydropower exploit the local resources, operate on small scale and have an advantage of meeting the needs of widely dispersed rural communities. The efficient use of electrical energy is very important issue in these situations because of the low level of power production capacity from these technologies and also due to the associated costs.

Light Emitting Diodes (LEDs) are rapidly evolving light sources. Increasing luminous efficacy, long life-time, and low power requirements make them suitable to be used for lighting in the rural villages. Cost analysis of LED based lighting systems driven with renewable energy sources in different parts of developing countries have shown them to be cost effective in comparison with the existing options [10]. The Light Up the World (LUTW) organization is one of the pioneer to apply LEDs for lighting in rural villages, and it has already lit up more than 14000 homes around the world [16].

ENLIGHTEN (Europe Nepal LIGHTing and Energy Network) was a co-operation project between universities from Finland, Lithuania and Nepal. TKK Lighting Unit coordinated this project where one activity was to combine LEDs with solar energy and to promote their use in rural Nepali villages in co-operation with Light Up the World Foundation (LUTW). LUTW was born in Nepal and it was the first humanitarian organization to utilize white LEDs in order to replace fuel based lighting in developing countries. Nepalese example of lighting an entire village of up to 30 homes with less energy than used by a single conventional 100 W incandescent lamp explains why LED technology is continuing to be popular in the rural areas without electrical networks.

Unlike the other technologies, LEDs started showing their applicability in lighting in the developing countries before coming to the developed country market. The low energy required by LEDs is the key point to make them suitable for sustainable lighting solutions to the most part of the developing countries which are still out of reach of electrical networks. Nepal is one of these developing countries, where people in remote rural areas depend on fuel based lighting (kerosene lamps, oil based lamps, and resin soaked pine sticks) to bring minimum lighting services at their homes. Fuel based lighting is not only inefficient and expensive but also a cause of many health problems due to the generated smoke.

5 LED applications

One interesting LED lighting application is their use in plant growth. Electric lighting in greenhouses is conventionally provided by discharge lamps (HPS), but with the use of LEDs totally new concepts of lighting are possible and also the quality of lighting can be optimised for different plants.

Greenhouse is a structure, usually made of glass, where the inside environmental conditions can be controlled for cultivation and protection of plants. This gives the possibility of cultivate crops in conditions close to optimal year-round. Greenhouses provide also protection against the sometimes harsh and each-day more unpredictable exterior climate conditions. Although optimal growth conditions are desirable, the fact is that in practice they are not always achievable due to technical or economical reasons.

At higher latitudes daylight availability during winter is a limiting factor. Therefore artificial light is commonly used to supplement or totally replace daylight in order to maintain or increase the plant productivity. Conversely, production costs should be kept low or reduced, if possible. This last factor is where efficiency plays an important role, and consequently also lighting.

In order to improve efficiency in greenhouses located at northern latitudes, several aspects should be optimized in the future, namely the isolation, ventilation, heating, cooling and lighting. Lighting is perhaps one of the factors with important energy-saving potential. The most common light source used nowadays in year-round horticultural industry is the HPS lamp, mainly due to the high efficiency and long lifetime. However its spectral quality is more appropriated for human vision than for plant growth applications. Additional limitations of HPS lamps are the mercury content, fragile, omnidirectional light emission, limited spectrum and light intensity control possibilities. For all these reasons LED-based luminaires are good candidates to replace HPS luminaires in greenhouses.

Today the main advantage of HPS lamps in relation to LEDs still is the electrical efficiency and light emission per lamp. However the potential efficiency of LEDs is increasing constantly. Future greenhouses will have to reformulate their automation systems in order to include spectral and intensity controls of the light sources. This will bring possibilities to growers and researchers as well as new challenges. The operation of the lamps will not be anymore limited to on or off but instead it will be possible to continuously dim according to daylight and weather conditions. Multispectral wavelength LED luminaires will allow to control and optimize the plant development at all different stages. Considering the large combinations allowed for control, computer-based control units will become more commonly used. This will facilitate the integration of the necessary systems required for optimization of the abiotic parameters inside the greenhouse. Future greenhouses may also benefit from the utilization of alternative energy systems, such as geothermal or wind energy.

A recent research showed the potentialities of LEDs as photosynthetic light source for plant growth in greenhouse and in phytotron [17]. The results obtained in greenhouse tests confirmed that utilization of red and blue LEDs as supplemental lighting was at least equally effective in accumulation of biomass as with HPS lamps. The addition of a third wavelength component in yellow to red and blue, gave the indication that further optimization for lettuce growth is still possible.

Additional experiments were carried out in phytotron conditions where plants were growth without the influence of daylight. The results have shown that under certain LED lighting quality it was possible to reduce the nitrate contents of lettuce plants significantly in relation to control plants grown under special fluorescent lamps.

In both studies the plants grown under LEDs had improved morphology than plants grown under conventional lighting. Also the carbonhydrates balance was better in plants grown under LED lighting.

6 Conclusions

Lighting is a large and rapidly growing source of energy demand and greenhouse gas emissions. At the same time the savings potential of lighting energy is high even with the current technology and there are new energy efficient technologies coming on the market.

To realise the savings potential of lighting we need international co-operation to find out the various aspects and possibilities of energy-efficient lighting. A new guidebook on energy-efficient lighting will be published by IEA Annex 45 at the end of this year. The guidebook is a result of co-operation between 21 countries worldwide. The guidebook is targeted for lighting designers, electrical building services and system integrators in buildings and the end-users/owners. It will include energy-efficient technical solutions for lighting and also possibilities for energy savings.

LEDs are seen as a future light source both for industrialized and developed countries. The low energy required by LEDs is the key point to make them suitable for sustainable lighting solutions to the most part of the developing countries which are still out of reach of electrical networks.

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MODEL TO DETERMINE LIGHTING ENERGY SAVINGS IN COMMERCIAL BUILDINGS

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Abstract. *The awareness of limited resources as well as the increasing political interest in energy-efficiency demand models for estimating the energy consumption of systems. World-wide activities look at the energy consumption of various economical sectors including buildings. This paper outlines an approach for estimating the energy consumption for lighting in a new building. Models like these face the challenge that they base their assumptions on the data provided by early design stages of a particular building. The estimate needs to be reasonably precise to enable a reliable comparison between a set of options. At the same time, the amount of input data should be minimized to allow for a good and easy usability.*

The model described in this paper uses the installed lighting power density, the area of the daylit and non-daylit section and the effective operational times during daytime and night-time for each building zone. The calculations (based on the German standard DIN 18599 and the North-American standard ASHRAE-IESNA 90.1) allow a trade-off within the field of lighting technologies. This methodology forms the basis for the lighting trade-off compliance path of the next edition of the National Energy Code of Canada for Buildings (NECB).

Keywords: **d***aylighting, energy efficiency of buildings, calculation methods, lighting controls*

I. Introduction

The energy consumption for lighting in buildings depends on the (variable) demand within a (given) time interval t_1 to t_2 as shown in (1):

$$Q = \int_{t_1}^{t_2} p(t)\,dt \qquad (1)$$

When using daylight dependent or occupancy dependent lighting control, the computation of the energy consumption for lighting can also be based on the installed electrical power for the lighting system [8]. The factor δ in (2) represents the average dimming level (ranging between 0 and 1), derived from the sensor signal x_{Sensor}.

$$Q_{light} = \int_{t_1}^{t_2} P_{\max} \cdot \delta(x_{sensor}, t)\,dt \qquad (2)$$

In a simplified manner, the computation of the energy consumption for lighting Q_{light} can be expressed as a product of the installed lighting power P_{max} and a quantity named effective operational time t_{eff}.

$$Q_{light} = P_{\max} \cdot t_{eff} \quad (3)$$

0 shows the transition from representing the energy consumption by the time-changing demand to the simplified multiplication in (3). The blue area in the graph represents the energy as calculated in the integrating approach and the red area represents the concept using the equivalent time of operation. Both areas are equal in size.

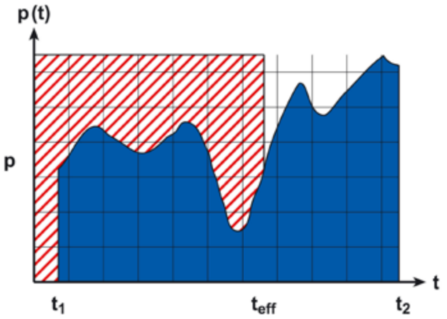

Figure 1 Transition to a simplified calculation of the energy consumption [11]

The advantage of this approach is the easy way of handling the electrical lighting system. It is characterized by the installed lighting power only. Note that this number represents the use of lamps, ballasts and luminaires but it excludes the effect of any lighting control system which will be accounted for in the equivalent time of operation.

The methodology needs to consider influences of daylighting and electrical lighting for a building zone. For this, the algorithm differs between daytime and night-time operational times. Within this methodology daytime is defined as the time during which the sun altitude is greater than 0˚. Conclusively, the daytime operational time or simplified operational time (day) is the daytime during which the building zone is operational. Daylight related savings can only occur during the operational time (day) and in those parts of the building zone that are classified as the daylit zone.

The effective operational times consider all applicable influences that limit the energy consumption for lighting, i.e. all operating control systems in a building zone. Equation (4) shows the basis of the lighting energy budget calculation:

$$Q_{light} = \sum_{j=1}^{J} p_j \left[A_{DL,j} \cdot \left(t_{eff,day,DL,j} + t_{eff,night,j} \right) + A_{NDL,j} \cdot \left(t_{eff,day,NDL,j} + t_{eff,night,j} \right) \right] \quad (4)$$

where:

p_j = installed lighting power density for the electrical lighting system

$A_{DL,jb}$ = area within the building zone that can be daylit

$A_{NDL,j}$ = area within the building zone that cannot be daylit

$t_{eff,day,DL,j}$ = effective daytime operational time for the area within the building zone that can be daylit

$t_{eff,day,NDL,j}$ = effective daytime operational time for the area within the building zone that cannot be daylit

$t_{eff,night,j}$ = effective nighttime operational time for the the building zone

Parasite effects such as energy consumption for standby luminaires are not being considered.

II. Overview of Canadian Standards

Canada has implemented several energy conservation standards that recommend/ regulate the use of energy-efficient lighting starting with the Model National Energy Code of Canada For Buildings in 1997 [9]. Since then, a few other standards have been installed to push the bar for energy-efficient technologies higher. 0 illustrates the impact of various standards on the overall energy-efficiency. The timeline is not to scale and the numbers are of general nature and might differ for different building/space types.

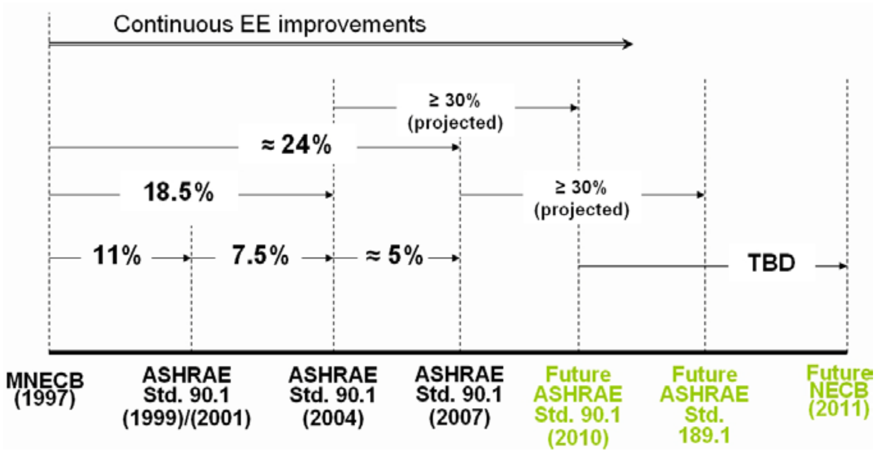

Figure 2 Overview of the main codes implemented in Canada to target energy-efficiency [12]

The main influence to date came from the implementation of updated versions of ASHRAE/IESNA Standard 90.1 by various municipalities. Recently, work on updating the National Energy Code for Buildings has started aiming at a new version of that code in the near future (the official release of the NECB is expected in 2011). In parallel to the prescriptive compliance path, cope compliance can also be achieved by the lighting trade-off compliance path. This path evaluates the energy consumption of the current building design and compares it with the energy consumption of a baseline building. For this path the design complies with the code if the energy consumption is less than or equal to the baseline consumption (as shown in Figure 3).

III. Determining the installed lighting power density

There are different ways of determining the installed lighting power density. One way would be to use the recommended lighting power density given by the ASHRAE/IESNA standard 90.1 [1]. This number could be challenged by a more detailed lighting design approach using standardized lighting design methods.

By allowing these two approaches, the lighting power density can be derived by either a table (prescriptive path) or, in order to challenge the resulting energy consumption, a different lighting power density could be used it can be backed up by lighting design methods. Hence, this methodology has an interface for new lighting technologies that are more energy-efficient [13].

Within the overall process of determining the energy consumption for lighting in a building, a hybrid approach of using the lighting power density from the standard ASHRAE/IESNA 90.1 in some building zones and using a detailed lighting design in other zones is acceptable.

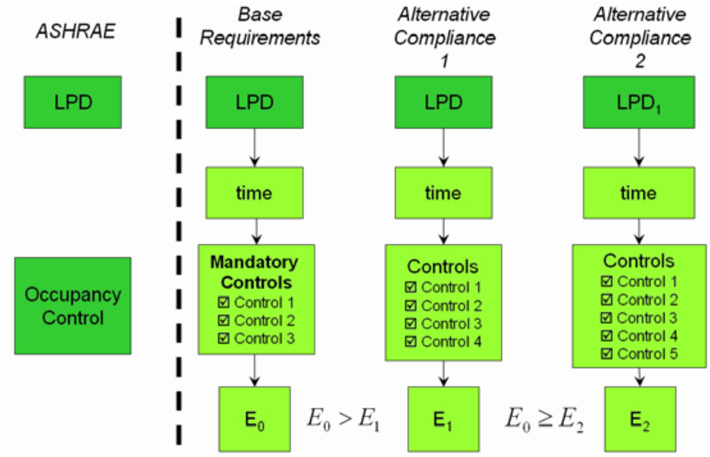

Figure 3 Comparison of the ASHRAE Compliance to the new Lighting Trade-off Compliance path

IV. Determining the daylit area

The total area A_j of a building zone consists of two sub-zones: one sub-zone $A_{DL,j}$ that could benefit from daylighting and the other one $A_{NDL,j}$ that cannot benefit from it (not in a daylit zone). The total zone area is the sum of the two sub-zones:

$$A_j = A_{DL,j} + A_{NDL,j} \tag{5}$$

Areas are considered daylit if the ratio of area depth and the difference between the top of the window and height of the working plane is less than or equal to 2.5. If the building zone has more than one transparent external wall, the determination of the sub-zones should be based on the largest fenestration area.

Zones uniformly equipped with skylights are considered daylit. For single skylights or wide spacing of skylights, the area $A_{DL,j}$ is defined as the area that meets the following criterion:

$$a_{DL,\max} = 2 \cdot \left(h_{c,j} - h_{wp,j}\right) \tag{6}$$

where:

$a_{DL,max}$ = maximum length/width of the daylit area

$h_{c,j}$ = height of the ceiling of the building zone

$h_{wp,j}$ = height of the work plane

V. Calculation of the effective operational times

The impact of daylight depends on the following quantities:

- Geographical location
- Meteorological situation, e.g. local sunshine probability
- obstruction
- daytime times of utilization
- relative activation level of shading systems during daytime
- installed daylight system
- daylight control system
- occupancy control system

The effective times of operation are the sum of the time of operation (day) and time of operation (night). Both quantities are weighted by operation factors accounting for the control system(s):

$$t_{eff,day,DL,j} = t_{day,j} \cdot F_{DL,j} \cdot F_{occ,j} \qquad (7)$$

$$t_{eff,day,NDL,j} = t_{day,j} \cdot F_{occ,j} \qquad (8)$$

$$t_{eff,night,j} = t_{night,j} \cdot F_{occ,j} \qquad (9)$$

where:

$t_{day,j}$ = operational time of the building zone j at daytime

$t_{night,j}$ = operational time of the building zone j at night-time

$F_{DL,j}$ = factor to account for daylight harvesting in building zone j

$F_{occ,j}$ = factor to account for occupancy control in building zone j

A. *Operational time*

The operational time is divided into day- ($t_{day,j}$) and night-time ($t_{night,j}$). This allows accounting for daylight harvesting only during those times when daylight is available. Daytime is defined as the time when the sun altitude at the location of the building in greater than 0.

The operational times depend on the start time and end time of the operation in the building. These times depend on the geographical location of the building. For Canada, there will be a few different geographical zones. For each geographical zone there is a set of tables to determine the operational times during day- and night-time. The tables assume 5 working days per week. Different operations need to correct these values linearly.

B. *Factor $F_{DL,j}$ for Daylight Harvesting*

The factor for daylight harvesting depends on two auxiliary quantities:

$$F_{DL,j} = 1 - C_{DL,\sup,j} \cdot C_{DL,ctrl,j} \qquad (10)$$

where:

$C_{DL,ctrl,j}$ = factor to account for the daylight dependent control system

$C_{DL,sup,j}$ = daylight supply factor

The daylight supply factor $C_{DL,sup,j}$ is a measure for the amount of daylight available in the building zone. This quantity is the same as the relative annual exposure [2], [3]. The factor to account for the daylight dependent control system $C_{DL,ctrl,j}$ relates to the performance of the lighting control system.

The values for these factors can be determined by simulation and sensitivity analyses. The data for the German standard has been computed by Jan de Boer of the Fraunhofer Institute for Building Physics [4]. For this, the daylight supply is evaluated using the daylight factor or another estimation method. The daylight suppy factor consists of two partial daylight supply factors $C_{DL,sup,SA,j}$ and $C_{DL,sup,SNA,j}$. These factors describe the daylight supply for the situation with an activated (SA) and a non-activated (SNA) sun shading system. These two factors are weighted by the relative times $t_{rel,DL,SA,j}$ and $t_{rel,DL,SNA,j}$ describing the relative time the daylight system is in either of the two states. The daylight supply factor is calculated as follows:

$$C_{DL,\sup,j} = t_{rel,DL,SA,j} \cdot C_{DL,\sup,SA,j} + t_{rel,DL,SNA,j} \cdot C_{DL,\sup,SNA,j} \quad (11)$$

where:

$t_{rel,DL,SA,j}$ = relative time that the sun shading system is activated

$t_{rel,DL,SNA,j}$ = relative time that the sun shading system is not activated

$C_{DL,sup,SA,j}$ = daylight supply factor for the building zone j if the sun shading system is activated

$C_{DL,sup,SNA,j}$ = daylight supply factor for the building zone j if the sun shading system is not activated

For a non-activated sun protection system the effective luminous transmittance for the daylight system is:

$$\tau_{eff,SNA,j} = \tau_{D65,j} \cdot k_{1,j} \cdot k_{2,j} \cdot k_{3,j} \quad (12)$$

where:

$\tau_{eff,SNA,j}$ = effective luminous transmittance for non-activated sun protection

$\tau_{D65,j}$ = luminous transmittance for illuminant D65 for the glazing type

$k_{1,j}$ = window frame factor

$k_{2,j}$ = dirt factor

$k_{3,j}$ = factor to account for non-orthogonal light incidence

The daylight supply factor can be looked up in a matrix with two variables: effective luminous transmittance and the target illuminance in the building zone. This factor can vary a lot for different systems. A simple table looking at product classes (e.g. sun protection systems, automatic blind systems, light redirecting systems etc.) can only point out an estimate. For a more detailed calculation, the relative annual exposure needs to be calculated.

The factor to account for the daylight dependent control system $C_{DL,ctrl,j}$ is derived in a similar way as the daylight supply factor by using tabulated data. The factor depends on the control system for the electrical lighting system, the qualitative daylight supply (good, medium, bad/none) and the target illuminance. The controls systems are divided into:

- building management system,
- automated control system with the ability to switch off the light,
- automated control system without the ability to switch off the light and
- manual control.

C. Factor to account for occupancy control

The factor $F_{occ,j}$ accounts for the influence of an occupant's absence from the building zone j on the energy consumption for lighting. This factor is being derived from the two other auxiliary factors $C_{A,j}$ and $C_{occ,ctrl,j}$:

$$F_{occ,j} = 1 - C_{A,j} \cdot C_{occ,ctrl,j} \qquad (13)$$

where:

$F_{occ,j}$ = factor to account for occupancy control in building zone j

$C_{A,j}$ = relative absence from the building zone j

$C_{occ,ctrl,j}$ = efficiency of the occupancy control to determine absence in the building zone j

Absence in the context of this methodology describes the relative time during the operational time during which the building zone is unoccupied. The factor $C_{occ,ctrl,j}$ models, how quickly and how accurately this absence is detected by the control system in place. For automated occupancy sensors, this factor is significantly greater than for the situation where the lighting is controlled manually by the occupant.

These values cannot be used for all room types under any circumstance. For instance, for the evaluation of a large open office space these numbers can only be applied if there is an individual lighting controls for every workstation. For a large open office space that is only illuminated with a general lighting system, $C_{occ,ctrl,j}$ is equal to 0.

D. Factor to account for individual controls

Following the same approach as for occupancy sensors, the model contains a factor $F_{ind,j}$ to account for the influence of individual controls. Individual controls enable an occupant to dim down his task light individually. Research has shown that there are significant savings (approx. 10%) due to this approach [7]. The model accounts for these savings if they apply. If the space has no individual controls, $F_{ind,j}$ is set to 1.

VI. Summary

The model as described in this paper allows the calculation of the energy consumption for lighting in a building. Equation (4) summarizes the general approach. A flowchart of the model based on this equation is illustrated in Figure 4.

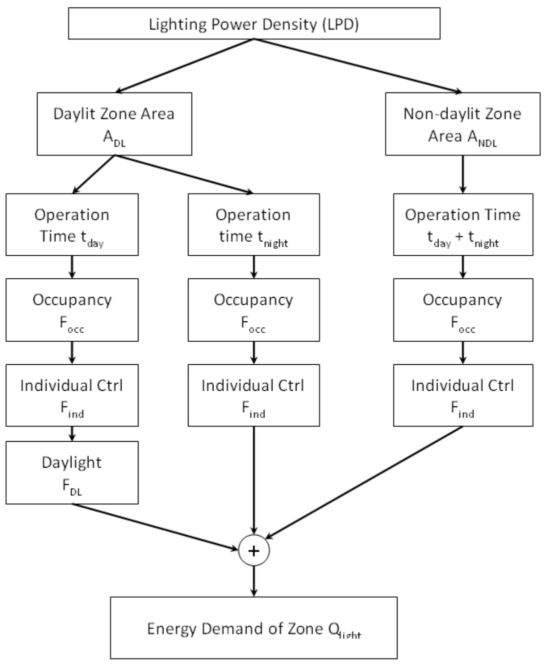

Figure 4 Flowchart of the methodology to determine the energy consumption for lighting of a building zone

For every building zone, the influences of electric lighting, daylighting and the lighting control system are being evaluated. This methodology uses the installed lighting power density, the area of the daylit and non-daylit section and the effective operational times during daytime and night-time for each building zone.

This methodology fits into the general building approach of the German standard DIN 18599 [6] forming the national implementation of the European directive on energy efficiency in buildings [10]. The calculations allow a trade-off of the energy consumption in between different technical areas such as lighting, heating and cooling. It also allows comparing the energy consumption of these different technical areas and to monitor the influence of different choices (e.g. installing a different technical system).

To evaluate the energy savings of a design, two situations, a defined base case and the current design, need to be evaluated. The difference in the energy consumption defines the energy savings to be expected.

VII. Acknowledgment

Most of the methodology described in this report has been developed at the Fraunhofer Institute for Building Physics and the Technical University of Berlin. The results of the combined research activities have become part of the German standard DIN 18599 allowing the energetic budget for buildings.

This paper also represents some of the current work of the task group lighting of the National Energy Code of Canada for Buildings. The model has partly been refined to fit into the general approach of the Code and to meet Canadian requirements.

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PHOTOMETRY OF SOLID STATE LIGHTING IN THEORY AND PRACTICE

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Abstract. *Solid state light sources get used in a number of applications, both as signal lights (e.g. traffic lights and displays) and in in- and outdoor general lighting. As the spectral power distribution of the LEDs differs from that of traditional light sources, the uncertainty of their photometric measurements is larger than we were accustomed up to now. Traditional photometry and lighting design does not take into consideration that not all human observers have the same spectral luminous efficiency function. In the present paper we analyze the differences practical photometric observers produce compared with receivers that simulate one of the typical human observers (e.g. 2° and 10° standard observer, observer with $V_M(\lambda)$ sensitivity, cone-fundamental derived sensitivity, or standard deviate observer). It can be shown that for practical white light applications the average photometers intended for field use (i.e. with an f_1' of < 3%) are adequate, the readings of these photometers will not deviate more from the reading of an instrument that conforms to the standard observer by more than what the deviation for most of the population will be.*

Keywords: *Photometry, spectral responsivity, spectral luminous efficiency function, spectral mismatch error index*.

1 Introduction

Photometry uses the 1924 standard photometric observer's spectral responsivity curve[1], restated recently with higher precision in a CIE/ISO standard[2]. Since more than fifty years it is known that the $V(\lambda)$ function (the spectral luminous efficiency function) is too low in the blue part of the spectrum[3] and CIE published a corrected spectrum in the form of the $V_M(\lambda)$ function[4]. Interestingly this function is still not in practical use, based mainly on the fact that for traditional white light sources the difference of calculated luminous flux is small if instead of the $V(\lambda)$ function the $V_M(\lambda)$ function is used. A further problem with the $V(\lambda)$ function is that it relates to small field (2°) foveal vision, but it is used also in peripheral and large filed of view situations, where the 10° observer should be used for luminance evaluation[5] and for brightness evaluation some more complicated functions should be used[6]. A further complication is the fact that for a considerable part of the human population the $V(\lambda)$ function is not representative for vision. Here we do not want to refer to deutans, only to those who have slightly deviating spectral sensitivity, described by the CIE deviate observer[78]. (Although there are reports that question the validity of the CIE deviate observer[9], we used it in our evaluation, as it is the only internationally accepted function.)

A CIE Technical Committee is working on cone fundamental based colour matching functions[10]. In this respect they evaluate the use of a physiologically-relevant 2 degree (and 10 degree) $V(\lambda)$ luminous efficiency function, based on the work of Stockman and co-workers[11,12]. These functions might replace at one time the aged 1924 function, and one should investigate the significance of a change using these functions.

With the invention of light emitting diodes (LEDs) light sources came onto the market who's relative spectral power distribution (SPD) differs considerably from those of traditional light sources. In case of white light sources constructed from red-, green- and blue emitting LEDs the SPD consists of three narrow spectral bands, one of which lies in the region where the $V(\lambda)$ function is in error, producing well visible discrepancy between visual appraisal and instrumental match.

2 Sources, detectors and test samples

2.1 Source spectra

Two groups of spectra have been collected: Warm White colour temperature light source spectra and daylight spectra. In both cases a CIE standard Illuminant (Ill. A and D65) was used as reference spectrum. To show the differences to traditional light sources in both groups fluorescent lamp spectra were also included. For both studies LEDs built from blue chips and yellow phosphors (p-LEDs) as well as clusters of red, green and blue emitting LEDs (RGB-LEDs) were used. Spectral power distribution of the test sources is seen in Figure 1 for the 2856 K group and in Figure 2 for the Daylight group. Colorimetric characteristics are seen in Table 1.

Table 1 Colorimetric characteristics of the sources used in the present experiment

Lamp designation	Correlated colour temperature, K	General colour rendering index, Ra	x	y
2856 K group				
Illuminant A	2856	100	0.4476	0.4420
Compact fluorescent lamp	2895	85.7	0.4420	0.4016
p-LED	2879	72.5	0.4508	0.4165
RGB-LED	2885	31.5	0.4466	0.4091
6500 K group				
D65 illuminant	6503	100	0.3127	0.3290
CFL	6081	73.6	0.3189	0.3514
p-LED	7153	79.6	0.3023	0.3240
RGB-LED	6782	46.5	0.3091	0.3212

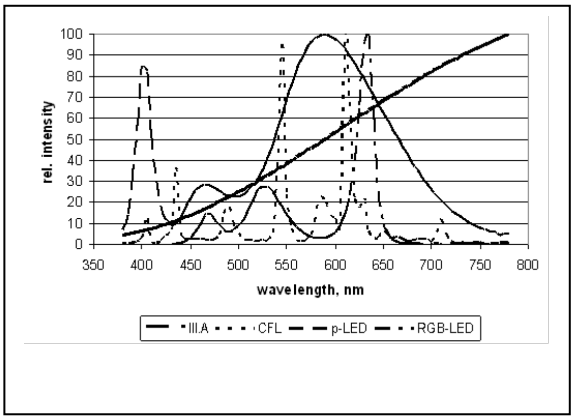

Figure 1 SPDs of the 2856 K group of sources

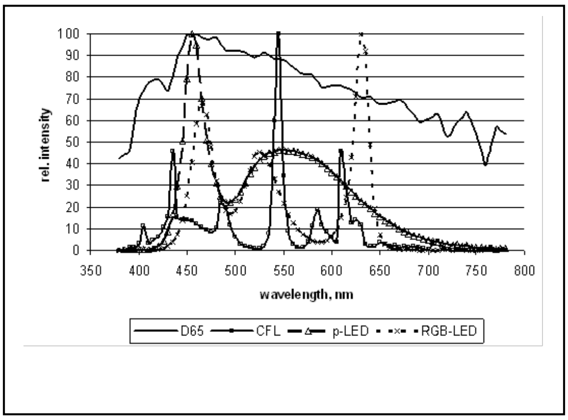

Figure 2 SPDs of the D65, CFL and two LED sources

2.2 Detector spectra

As reference the CIE 1924 spectral luminous efficiency function ($V(\lambda)$) was used to evaluate photometric characteristics. As test spectra the $V_M(\lambda)$-[4], the $V_{10}(\lambda)$-[5], the cone fundamental based V*(λ)-function[12], the first CIE 10° deviate observer spectral responsivity function ($y_{10,d}(\lambda)$)[7], and several real photometer responsivity functions have been selected. Figure 3 shows the spectral responsivity curves of the theoretical eye-responsivity functions. Figure 4 shows the spectral responsivity of the real detectors, here the detectors are characterized by their spectral mismatch error indices, f_1', based on the CIE recommendation to use for the $V(\lambda)$ function the standard Illuminant A as reference source[13].

Table 2 shows the tabulated f_1' values for the theoretical and practical receivers.

Table 2 f_1' values of photometric functions and detectors used in the present investigation

	$f_1^{'}\left(V(\lambda)\right)$
$V(\lambda)$	0
$V_M(\lambda)$ function	0.73
$V^*(\lambda)$function	5.65
$y_{10,d}(\lambda)$ function	9.47
$V_{10}(\lambda)$ function	9.51
CCD luminance meter-1	1.18
Photometer-l	1.2
y-channel of a tristimulus colorimeter	1.35
Photometer-2	1.7
Photometer-3r	1.87
Photometer-4	2.27
Photometer-5	3.01
CCD luminance meter -2	14.26

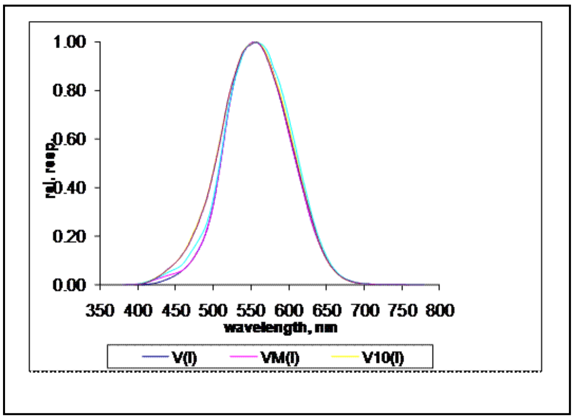

Figure 3 Spectral responsivity curves of the $V(\lambda)$, $V_M(\lambda)$, $V_{10}(\lambda)$, $V^*(\lambda)$ and $y_{10,d}(\lambda)$ functions

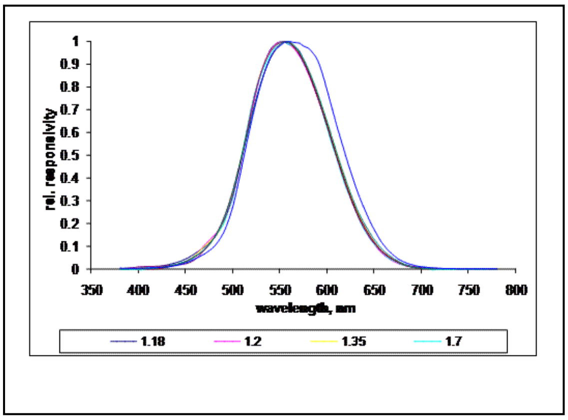

Figure 4 Spectral responsivity of a number of Si-photoelements and CCD arrays adjusted to the $V(\lambda)$ function, detectors are qualified by their f_1' values

3 Experiments and discussion

3.1 Spectral mismatch error index evaluation

The simple comparison of the f_1' values of the different theoretical and practical detectors permit already some interesting conclusions: The $V_M(\lambda)$ function corresponds to an extremely good detector, usually not realizable in practice. But the tentative $V^*(\lambda)$ function deviates considerably from the standard $V(\lambda)$ function, it would not been accepted in most practical applications. Interesting is also that the f_1' values of the $V_{10}(\lambda)$ function and its deviate observer function are practically the same. There was only one CCD luminance meter that had a bigger f_1' value than the theoretical functions. This shows that for many applications one requests "better" instruments then the human eye, or one uses instruments that do not measure the quantity one is interested in (e.g. large filed illumination measured with 2 observer illuminance meter).

3.2 Photometric evaluation

Present standards prescribe the use of the CIE 1924 standard photometric observer to evaluate light source performance, irrespective of the viewing situation, and instrument manufacturers are forced to mimic the $V(\lambda)$ function, although in many situations the use of an other function would be more appropriate. Our endeavour was to compare the photometric values of detectors with different goodness of fit (f_1' values) of the $V(\lambda)$ function with those values one would obtain by using other spectral visibility functions. In this respect we calculated the spectral integrals of the following form:

$$\int_{380\,\text{nm}}^{780\,\text{nm}} S_\lambda s(\lambda)\mathrm{d}\lambda \qquad 1)$$

where S_λ is the SPD of one of the light sources shown in Table 1 and $s(\lambda)$ the spectral responsivity of the photometric functions and detectors (see Table 2). Data were normalized to data obtained with the CIE 1924 standard observer function.

Figure 5 shows the differences detectors and photometric functions with different f_1' values will produced if calibrated with CIE standard Illuminant A and used for measuring light produced by different light sources. The errors of the measured values using all functions and detectors with f_1'<3% will show the correct value within a ± 2% range. Even detectors and photometric functions with f_1'<6% can be used safely with the tested white light sources. The situation is quite different if we use a photometer designed for the 2 observation in a situation where a large filed observer would be more appropriate. For the daylight sources (both real daylight and produced by p-LED or RGB-LED) the differences become 2 – 3 times higher. This should be kept in mind if one compares the effect of different light sources in different applications.

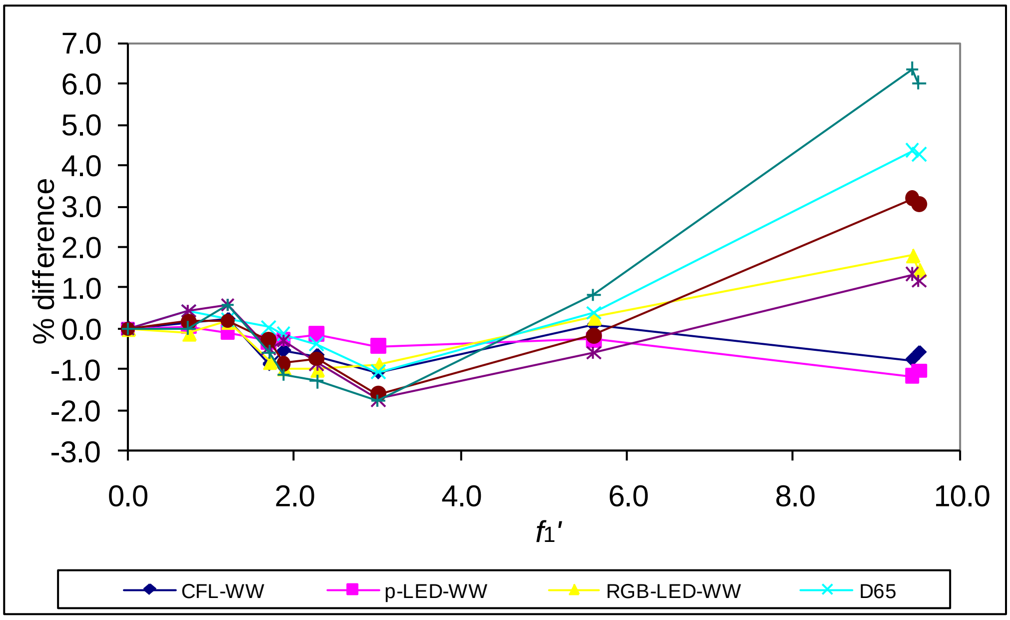

Figure 5 Per Cent difference of measured photometric values for the different light sources in case of the detectors and photometric functions relative to $V(\lambda)$ and CIE St. Illuminant A

4 Conclusions

In this paper we analyzed the effect of spectral responsivity on measuring accuracy if samples are irradiated with different light sources. As could be shown the visual mechanisms (foveal and para-foveal vision) and errors in the standardized spectral sensitivity curves show larger deviations as differences produced by general purpose instruments.

From our investigations we can conclude that illuminance and luminance measuring instruments with spectral mismatch error indices smaller than 3° will provide measurement results that show smaller scatter than produced by using a non-appropriate spectral luminous efficiency function. In this respect it is of particular importance that a change from the 1924 spectral luminous efficiency function to the $V^*(\lambda)$ function will not produce – at least for the tested light sources producing white light – a difference bigger than ±1%. The question might be different if colorimetric effects, either produced by coloured lights, or by shining white light on coloured surfaces are considered, but this is beyond the scope of the present paper, some aspects of this will be analyzed in a subsequent publication [14].

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During the nineteen eighties and nineteen nineties he worked for the International Commission on Illumination (CIE) as its General Secretary and later technical manager. He functioned also in a number of honorary positions of the CIE. From July 2007 he is the Vice President Technical of the Commission, chaired and chairs several Technical Committees, among others dealing with fundamentals of photometry, colorimetry and colour rendering. He is the Honorary President of the Lighting Society of Hungary.
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WHAT THE ARCHITECTS ARE EXPECTING FROM THE ARTIFICIAL LIGHT?

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Technical University of Cluj-Napoca

Abstract. *Working with light is not easy. Should it begin with architects and end with light engineers, or vice versa? Shall we find other ways to improve visions and predictions about our projects? It certainly evolves and we think that some thoughts of the architects may put some light upon an overview. How can we help intuition, use experience and references, success stories, as well? The discussion about sustainability risks to be sometimes a kind of subject which everyone understands, but each person tumbles in a different way. It happens so with every comprehensive notion, quite old or new, with dynamic, whom perception cannot be but holistic, as architecture, for example.*

Keywords: *architecture, sustainable lighting, light and art*

Introduction

We tried to separate from the concept coverage “sustainable lighting” a few ideas resulting from a dialogue between the architects (authors), who have tried to systematize the wishes and the expectances from the lighting domain. We added some utopian and speculative ingredients too, but we know that the border between the science fiction and design is not defined clearly anymore. Starting from big to small, from general to detail, we should talk firstly of the light culture.

1 Light culture

This should rejoin the interference principles of the specialists in the light production with those who implicate them in the project, designers, but also the critical opinions and the final users challenges as well.

The light culture should be remarked distinctly, unifying the efforts which are starting from the industry and sale with those from research and creation. The light is selling, like any other product or service, the concurrence generating performance, more and more also from the energetic and financial crisis which puts the accent on the efficiency. We are talking much more about the intelligent light or we should talk about the advanced light.

The light culture needs what is motivating the issue and disposes the principles in any cultural, critical and theory domain. A critique of light should be interesting distinctly of the architectural space critique or of the design.

At the end of the year 2008, after the city hall of Cluj has decorated the public spaces with festal ornamental lights, the press has reacted quite strongly, interrogating the public and the specialists, trying to discern about the “operation” quality.

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Figure 1 Liberty Center, Bucharest, 2008, Ostick & Williams and Dico si Tiganas, architects. Space as a giant screen for light projections

The City Hall representatives have told that they succeeded to supply quite a lot of light to very low prices and with consumptions remarkable low. For the first time, the public has commented discontent of the colors and telling that he does not recognize the elegance seen in Vienna. Being interrogated, we answered that also this Christmas will go and perhaps that next year will be different, counting much more the current lighting and the gestures hardly reversible than this ephemeral actions, which can be seen through an objective critique as experiments.

Figure 2 CFR 1907 Cluj, Stadium, 2008, Dico si Tiganas, architects. Different light interplays

2 Light theory

After the critical accumulation it should be interesting a theory of light with history, evolutions, styles, currents, courses and avant-garde. The validated principles should be organized and structured, rejoining the perception elements, the composition, technology, norms and study of case about the masters works. theory has always the role of guidelines, we need.

Hereinafter, we grouped some ideas of the discussion about what the architects are expecting for, from the light under the titles: architectural design, energy, object design and art.

3 What do the architects expect from light?

3.1 Architectural Design

The architects need operative instruments in order to help them to integrate the light in the projects and to work with it, as being a true construction material.

They need of the capacity to operate with the light in the concept phase, sketchily, approximately insightful and quite easy.

One of our displeasures is that almost always we intervene with the study of light and of installations necessary tardily after the space was been configured, trying only adaptation, corrections and scenography on an imposed stage. Thereby, the light does not contribute as generator to the space configuration but only to the final exploitation. How can be surmounted this failure?

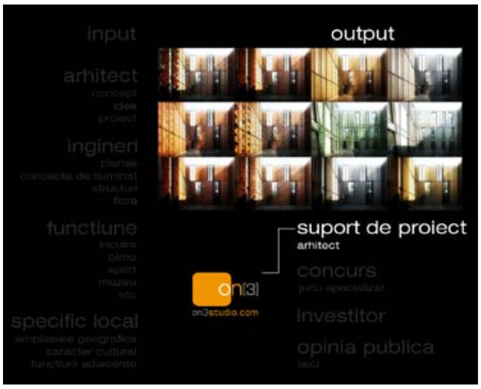

Figure 3 on (3) studio, Hamburg, image making concept. From the exhibition in Cluj Napoca, 2008.

We need simulation instruments to a conception level, but also of the theoretic guide support with references and examples. It is necessary a quick software, friendly, unsophisticated, which should captivate the unprofessional of light to the conceptual work with it. Hereinafter we need other instruments which should permit comparisons, options and decisions for the concepts adopting and not to send later, after the projects development to the habitual exit from the budget and the cancellation of ingredients which should make the concept being possible. We need indicators of generic costs, of classes for the lighting concepts or levels, e.g.: basic, normal, minimal, innovative, advanced, ultra performing. The intimate cultural component has his place in these levels. We need to be able to propose general budgets, in function of the theme expectance. All these should be synthesized in INDICATORS for the lighting conception.

3.2 Energy

The LCC concept, Life Cycle Costs must be extended to the lighting systems. As architects, we are interested how much costs the initial investment, the unitary energetic consumptions costs and along the construction functioning, the maintenance costs, sustenance and repairing. Without indicators and relevant methods of calculation, of CAD and BIM instruments, everything remains between intuition and personal experience. If we look towards the car industry we can see how clear are clarified the problems there: initial price, class, performances, consumption, safety, insurances, fees, buy-back values and subjective indicators of quality perception. We should believe that things are simple. They became simple due to a car culture well organized, global which get into the profoundly acknowledgment of the public. Even the children admit from tender ages the car brands, their performances and they have clear options. Why we should not have something similar for architecture and our actual subject, such as the sustainable light?

Figure 4 Light advertising for no light

3.3 Object Design

The light is source and effect. It is always dual, corpuscle and wave, necessity and decoration. The light signifies also the lamps design or the lightening devices which should signify anything in objects domain. The unconventional and the innovative have invaded the domain. We are talking about systems, accessories, command, interactivity, meaning about the high-tech zone but also about tradition, style, correspondences. We need lamps. We need good products delivered by the industrial design, unique one or products with signature and lamps which can be created or adapted for certain brands. We need adequacy possibilities of the lamps to the character of an architectural work. The lamps shall be applicable with the time spirit, with the lifestyle, apparel, perfumes, watches, vehicles and music. We would like to visit a museum of lamps of always and from everywhere, but to participate also to show-room exhibitions or even on the catwalk.

3.4 Light as Art

The light is an artistic domain. Public, private, of collection, static or in movement, the light is spectacle when it is thought. The meeting between the light and the public remembers of the speleologist incursions in the underground world dipt generically in obscurity. The acknowledgement, the physical and metaphorical discovery were present through the carbide lamps from the explorers headpieces and the magnesium flashes of the cameras. The universe of the fluid sculptures formation realized to the geological speed of the planet has became biotic in the light. Look a complex experience with an important emotional component. If exists a photographical art, a cinema art based on the light, called strongly "the seventh art", why should not be exist even the eighteenth art, the dance, all the performing arts, trying sometimes to be a subject itself. We think that this state must be consolidated.

Figure 5 Bosh Rexroth Factory, Blaj, 2007,
Dico si Tiganas architects. Involuntary light effects

4 Crazy ideas

Finally, some ideas: speleologist, ballerina, anniversary cake and the barometer.

The "speleologist" is a frontal lamp which wares on head, on the coiffure, hat, cap or elastic support, being able to create a vague hallow, ambient but also being able to lighten continuously or when requested, like the far beam of vehicles, guided, if the person likes to read or to look for something. Carrying a torch, a handlamp, a candlestick is something known. The speleologist lamp should be agitated, put on the desk, used as static, when it is undressed. The lamp is attached directly to the person. In our absence the light is not necessary. It is an idea for the personal lighting, adaptable.

The "ballerina" is in the middle of the lighting circle of the stage projector: "In the spot light". This follows her movements, evolution, emphasizing her into individuality and importance. We understand again that the light has no sense in our absence and the seeing, in this case of the sight, of the concentrated attention. As the video cameras can follow us in space, the technology of the sensors combined with the computation had generated automatic technologies of orientation. Let's imagine that on the road we should be guided by the guided light of spotlights , on the sidewalk. Their intensity should vary depending on the cram and hour. It is an idea for the interactive.

"The anniversary cake" wares a lot of figures and it is accompanied with candles. It is full of symbol, centripetal, being as an ephemeral jewelry which marks a moment. The anniversary torte is an hour which we devour after the candles were been damped down , getting down the moment, digesting it. How should appear a ritual lamp, anniversary, inedible but compensating this with interactivity and adaptability? How should it be to have each of us the anniversary lamp which we receive in a certain moment and we take it with us, by adding glowing components with the time march? It is an idea for an object possible traditionally, based on light.

The "barometer" is that incompre-hensible device which tells us precisely based on millimeters mercury what happens with the weather by using anterior references. We always felt that it needs a translation in order to be understood by everyone. How should appear a "barometer" lamp which shall indicate us the weather tendencies and to be emplaced in the public area, littering cold or hot light, announcing the storm, the orange code or the heat summer? It is an idea for the informational public lighting, expressly coded.

Are you expecting to find out something unknown from the unpronounced secrets of architects? We don't think so. The way between ideas, extravagances, projects, consecrations and traditions is long and discontinuous but fascinating. It is astonishing how we are progressing due to the war, disasters or wishes of new adventures and pleasures.

5 Don't forget to…

Our final invitations: procure the Encyclopedia of light, unwritten yet, visit the global Museum of light culture, in course of invention and don't refuse yourselves , sometimes, an evening to a restaurant with glowing specialties, where the senses interfuse in a sophisticated manner into glasses and plates, which for the moment are seeking for a chef.

Figure 6 Tiago Mall, Oradea, 2008 ,
Ostck & Williams and Dico si Tiganas, architects

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Şerban ŢIGĂNAŞ combines his architectural concerns as designer with the education of architectural students, and, in the last decade, with the environment of the architectural practice. What may define him is the team work and the permanent will to go deeper, and, also, to look from above and generalize the experiments he makes. His interest for the light covers project scale and urban scale of the city. He contributes to the light design culture in Romania by projects and theoretical experiences. A special interest goes to ephemeral architecture, of which light is a strong component, sensitive and changeable by its temporal dynamic.

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Dana OPINCARIU, architect, works in education; her interest is oriented towards interior architecture and form study but, also, in the architectural representation, drawing and perspective. She combines practical experiments with the students with theory always at the edge of classical methods and surprising innovation. Architecture is for her detail and materiality, texture and colour, all in a composed sensorial perception. The light is a permanent component in space which emphasizes or changes it by fine tuning. For Dana OPINCARIU the space is structured by light starting from intimacy, passing by proximity towards totality.

ROMANIAN LIGHTING CONVENTION 2011

Dorin BEU
Chairman of the RLC 2011

Since 2001 till 2009, the Lighting Engineering Center from Technical University of Cluj-Napoca has organized the ILUMINAT conferences every two years. To continue this idea and in order to enhance the importance of lighting among architects, designers, city councils, decision makers and so on, we have decided to make a bigger event – **Romanian Lighting Convention 2011.**

This event benefits from the support of International Commission on Illumination (CIE), Romanian National Lighting Committee but also, for the first time, Professional Lighting Designers' Association (PLDA), Architects' Chamber of Romania and Romania Green Building Council (RoGBC). The sinergy from putting together all this organizations will create an exceptional occasion to promote and understand lighting and to meet people interested in this topic.

Lighting companies, architects, engineers, lighting designers, lighting representatives from local authorities and building contractors are expected to attend RLC 2011 on May 18-20, 2011, in Bucharest, at JW Marriott Bucharest Grand Hotel. They all will approach the main topic which concerns "Light and community" under various aspects: lighting and architecture, public lighting, LED technology, lighting objects design, sustainable lighting, the Lighting Designer.

The Convention will also include an exhibition with state-of-the-art products, a XX Century Lighting Design Icons gallery held at the Architecture University and a lighting application contest.

In order to encourage both young and experienced professionals in creating original, efficient and quality lighting works, the organizers decided to give them a boost by developing a series of contests. These are either based on previous projects that contestants made or, as the LED Design section, on original lighting designs.

Details at www.rlc.org.ro.

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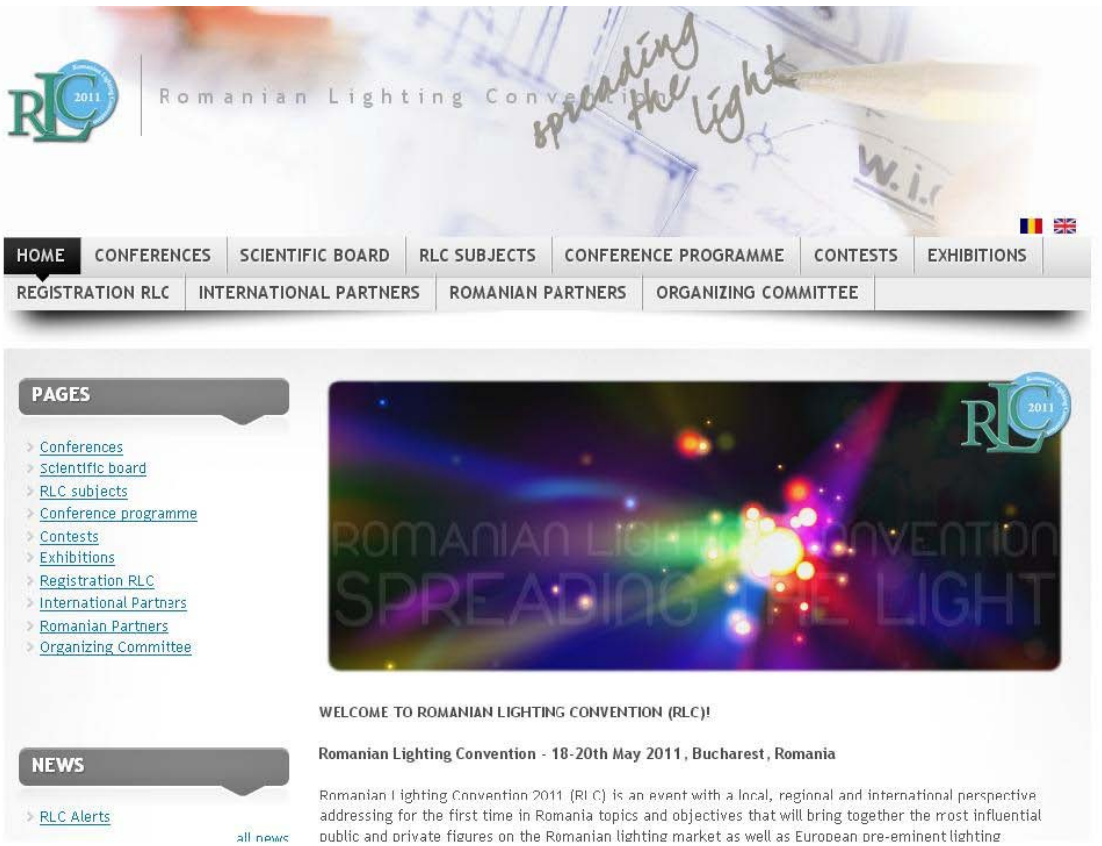

LIGHTING IN THE NEW WORLD

Cristian ŞUVĂGĂU
BC Hydro, Vancouver

LIGHTING THE FUTURE

Well, we are now in 2010. We do not need a crystal bowl to predict the future in lighting! What we need to do is look around. For lighting the future is happening now - cold cathode replaceable lamps in commercial and residential applications, induction luminaires in industrial settings LED luminaires for roadway lighting, and many other new applications. These technologies either did not exist or were just emerging a decade ago, at the dawn of the Millennium.

In lighting, however, the evolution of technology is not at all linear. Its development history been marked by big lapses and breaks. It is the last decade that has experience a bold push of emerging technologies such as Solid State Lighting (SSL) devices, digital addressable fluorescent ballasts or wireless commercial controls, to name just a few.

This is part of a planned future. We are at a mid-point of the 2020 technology roadmap, a 20-year North American industry plan for lighting technology. This initiative was fostered by all big industry players, from the Illuminating Engineering Society of North America (IESNA) to the International Association of Lighting Designers (IALD) to the National Electrical Manufacturers Association (NEMA) and the U.S. Department of Energy.

As with any technology roadmap, we soon find barriers and challenges and we have to develop strategies to overcome them in order to successfully transform the market. Reading the 2020 Vision document (http://www.nrel.gov/docs/fy00osti/28236.pdf) reveals what these challenges and strategies could. But I would like to venture to my personal 2020 lighting vision.

To paraphrase a famous quote of the French writer and philosopher Andre Malraux, “if the 21st century will not be energy efficient it will not exist at all”.

Briefly, today’s reality of climate change and scarcity of resources dictates that mankind needs to seriously reduce the energy consumption, as well as the ecological footprint, of material production. Net zero energy consumption in buildings and completely recyclable luminaires are being avidly researched today, giving us strong hope for tomorrow.

Technology-wise, solid state, digital and wireless are going to be the standards for tomorrow’s lighting. Using LED or Organic LED engines, the solid state technology of the future will enable an unparalleled level of controllability and

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flexibility to deliver quality lighting to the users. Besides the classical meaning of dimming, SSL sources will have the ability to modify the colour temperature of the light to match the circadian needs of buildings' occupants or to dynamically change the appearance colour to match occupants' moods or artistic inclinations.

OLED luminaires will start to advance from the decorative realities of today's technology to the mainstream of general/ ambient lighting. One could hope that not to distant in the future , ceiling tiles made of OLED engines can be easily use to provide illumination.

Side and core daylighting-enhanced lighting systems can complement them offering a healthy, natural continuation of outdoor activities indoors. Overall, it would be ideal that, for building occupants, the terms "day lighting" and "artificial lighting" to simply and naturally be referred to as "lighting".

Fluorescent and HID technologies will survive only with digital ballasts in order to compete with their solid state counterparts. Committed to a continuous reduction of the mercury content, lamp manufacturers will develop equipment with increased energy efficiency, longer life and superior lumen maintenance (for HIDs and CFLs).

Addressable digital ballasts, likely common equipment for all forms of discharge technologies of the future, will enable achievement of significant energy conservation goals as they will easily interface with occupancy and daylight harvesting controls.

On the controls front, the wireless ability to connect lighting equipment within the building or to adjacent buildings will be a commodity of the future. Open protocols will enable the "plug-and-play" connectivity of digital lighting sources (SSL or discharge ballasts) to control sensors and actuators. Moreover, modern building management systems will enable older, non-digital equipment to easily interface with digital equipment thus allowing not only energy savings but a greater flexibility of (individual) control for the occupants.

Lighting design, however, will see the most extraordinary advancements. The use of SSL technology will require and also enable a true paradigm shift of how lighting is provided. For example, OLED sources could be in the form of ceiling tiles or wall panels and can be easily replaced or re-arranged by end-users using a wired power network embedded in architectural surfaces. And if the use wants even display a gorgeous tropical blue sky or sunset…

The smaller size of SSL luminaires will allow an easier and more efficient illumination of tasks, reducing the need for a bright ambient component and saving important amounts of power and energy. The same design coupled with a control network could provide an individualised illumination that will follow people as they travel through the space.

For area and roadway applications, this glimpse of the future is almost here, as LED luminaires with motion sensors can turn on and off as a presence is detected along the way.

What we do not want to see

In imagining a better future, we must open ourselves to the idea of change. As there is no perfect present, one can only hope for an ideal future; however, we must mitigate today's issues:

Efficiency metrics: a 100-year old definition of the lumen, a metric developed for photopic vision, does not support the realities of the present, let alone the future. While most of human activities supported by artificial lighting are under mesopic vision, it is natural to consider a metric for luminous efficiency born under this realm. Currently, IES has commissioned a sub-committee of the Roadway Lighting Committee to investigate the mesopic vision benefits for white light sources.

Value engineering concept: today value engineering is a necessary evil designed to balance capital construction resources; however, value engineering should not have a place in tomorrow's lighting design. Integrated design practice should be the norm, ensuring that all stakeholders' needs are considered and balanced for a healthy budget that also consider life cycle cost accounting, not only simple payback, as today.

Energy codes: the narrow vision of efficiency based solely on restricting demand (W per area unit), neglecting the actual contribution of controls, cannot continue. Utilities are charging customers based mainly on their energy consumption. This needs to be reflected in the energy code metrics (kWh per area unit). This way, designers and owners will not be penalised for an efficient but layered lighting design. The 2011 Canadian National Energy Code is one standard that is expected to incorporate this metric. Moreover, using smart metering, utilities will develop tariffs that will reward customers with flexible time of use consumption that will keep the load peaks at bay.

Occupants' behaviour: The irony, unfortunately based on human nature, is that in places where energy costs were historically low, nobody cared about waste. For everybody else, this is sadly not a joke. Adding automatization to make sure that simply housekeeping rules like (manually) switching off lights when rooms are un-occupied are simply relief to energy efficiency, but even this can quickly fail when facility operators do not continually maintain their systems. Behavioural marketing programs are a must, however the education for a sustainable future should be brought more rigorous in schools as early as possible. It is afterwards the care for next generation that has to be paramount to our activities.

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