# STATUS OF LIGHTING EFFICIENCY STANDARDS AND GUIDELINES IN EUROPE

Ir. M. van Ooyen
Philips Lighting B.V., Eindhoven
The Netherlands

Ir. J. Vermeulen
Philips Lighting B.V., Eindhoven
The Netherlands

## ABSTRACT

Before discussing the actual status of lighting-efficiency standards, they are set in the right context. A distinction exists between the U.S.A. and Europe as far as these standards are concerned. In Europe none of these standards exist. This might be explained from the difference in approach to lighting in these two regions.
Setting a lighting efficiency standard alone does not mean that the optimal lighting-efficiency will be obtained.
It will be shown, that lighting recommendations designed to obtain adequate seeing conditions and adapted to the local demands enable intelligent use of energy.

## INTRODUCTION

In nature, high-quality energy from the sun is converted, together with carbondioxide and a few nutritious substances into organic material which in its turn provides energy for other creatures who will produce and finally turn into nutritious substances themselves. A perfect cycle which is activated by an almost unlimited source of energy, the sun.

We the human beings of today have created an artificial world. We have created highly sophisticated shelter to live and to work in, with heating in the winter and cooling during the warm season. Architects have given shape to this world and their creativity is almost unlimited. The kind of shelter we build generally requires artificial lighting at many places even during daytime.

This is true of course for the indoor world but also for the outdoor world. Landscapes have been drastically transformed into townscapes and as life does not stop after sunset, many lamps and luminaires guide us through this new world.

This is one side of the story, being the result of our efforts, hopefully beneficial to everybody involved. The other side of the story is, "what does it cost?" It is not in the first place the monetary aspect of this cost but a more general one. What are the resources that we use for our benefits. Of these resources only one will be discussed here, Energy. And even here a restriction will be made, only the energy that is needed to run our artificial work. The energy needed to build it is not considered. In contrast to the natural world, in this case the sources are not unlimited.

## LIGHTING AND ARCHITECTURE

A final restriction will be that we will only consider the energy used for lighting. This however cannot be done without a few considerations about lighting and architecture.

Relative large glass surfaces in the facades of buildings allow for a significant penetration of daylight and can contribute to reduce the energy demands for lighting. This is a positive effect. On the other hand, the high heat losses during winter and the high heat gain during summer put an extra burden on the energy demands to upkeep an acceptable thermal climate.
In non-optimal building designs, these extra energy demands can be much higher than the extra energy demands for lighting in a building with relative small glass surfaces. This is an appeal to all architects. Please be aware that Energy Efficiency starts at your drawing board! Optimal use of daylight is only possible when the

percentage of the glass surface areas are designed in relation to the glazing used and the choice of the non transparent facade material.

## LIGHTING AND HUMAN BEINGS

Many of the professional lighting installations are meant to enable the human being to perform his or her normal work. Most of these activities are related to visual tasks and lighting recommendations are based on these requirements. In general both the national and international lighting recommendations assure sufficient lighting quality to perform the needed visual tasks and therefore are related to productivity. This statement is put forward because we may never sacrifice the lighting quality for the sake of energy conservation, because it may end in penny wisdom and pound foolishness.
Lighting-efficiency must be based on the function of the lighting installation.

## ENERGY MANAGEMENT

Energy is the product of power and time.
Therefore, efficient or sensible use of energy has two aspects
a) How much power is needed to achieve a certain effect (in this case a lighting effect).
b) How to manage the time that this lighting effect is in use.

The first aspect of course is influenced by the choice of lighting equipment. The use of lamps with high luminous efficacy, the use of electronic gear, the use of efficient luminaires and light effective architecture are all means to reduce the power needed for lighting.
The second aspect generally is neglected. It cannot be sufficiently stressed that flexible lighting systems, being possible with modern electronic lighting equipment, can have a very positive effect on efficient energy use for lighting.
Many offices are furnished for a dual task. The most obvious task is reading or writing. For this task illuminance levels of 500 - 750 lux are required. However also meetings with 2, 3 or 4 people take place in these offices. What's the use of 750 lux at the desk at that moment? However not many offices even have a simple switch to adapt the lighting to the actual situation.

## STANDARDS FOR ENERGY-EFFECTIVE LIGHTING IN EUROPE

Above mentioned considerations are necessary to put the concept of standards for energy-effective lighting in the "right light". For example a standard giving values for the power per unit area floor surface of a building to be installed for lighting purposes is only one aspect of the total consideration of energy-effective lighting.
Strictly speaking, such a standard only can reflect the state of the art of lighting technology at a certain moment in time. Setting standards of this kind therefore only avoid excessive use of energy and nothing more. But also nothing less!

The implication of the word "standard" is not the same in all countries. For the sake of clearness if the word "standard" is used in this paper, it has a mandatory meaning. Words as "recommendation", "guideline" and "code of practice" have no mandatory meaning.

So how is the status of Lighting-Efficiency Standards in Europe?
During the research for this paper, contact has been sought with a number of people and organisations both in the Netherlands and other European countries. These people and organisations, like the Netherlands Agency for Energy and Environment and the Agence International de l'Énergie in France, are involved in use of energy. In spite of their efforts it has not been possible to trace in Europe, unlike in the U.S.A. the kind of standards that is looked for in the context of this paper.
Therefore it can be stated that (most probably) at this moment in Europe none of these standards exist.

## THE U.S.A AND EUROPE

Why is there such a difference between the U.S.A. and Europe?
A possible answer to this question may be the following. Much of the work that still forms the basis for the recommendations for professional indoor lighting (office- and industrial- lighting) has been performed in the sixties.
The results for office lighting can be summarized as follows:

The most preferred illuminance level is between 1500 and 2000 lux.

In most of the European recommendations this figure has been rounded off to 1000 lux whereas at that time in the U.S.A. values up to 2000 lux have been recommended. Seen in this light, the energy used for office lighting in the U.S.A. per m2 has been up to twice as high compared to the situation in Europe. Also Europe was earlier than the U.S.A in using the modern lamp technologies at a large scale. This may have caused a more urgent need in the U.S.A. for mandatory standards.

## ILLUMINATING SOCIETIES

It has to be found out now which organisations in and outside of Europe do influence the recommendations for lighting and to what extend the concept of energy conservation has an impact on the results.

**Table 1**

| | | |
|---|---|---|
| World | CIE | |
| "regional" | - | Europe |
| | NSvV | The Netherlands |
| | LiTG | Germany |
| | SLG | Switzerland |
| | AME | France |
| | ... | ... |
| | ... | ... |

Tab‹; 1 gives a few of the Illuminating Engineering societies. The list is of course much longer. The Scandinavian countries for example have very active light technical societies.
Most of the industrialised countries do have a national lighting committee that is representing the country in the "Commission Internationale de l'Éclairage" or the "International Illuminating Committee", the CIE. Also countries like India and Thailand are active members. In total 37 countries. See[1].
If Europe is called a region then the conclusion must be, that at this regional level no Illumination Engineering Society exists.
The CIE produces, amongst others, publications which are classified as "Recommendations" and "Technical Reports". The technical reports can be considered as "State of the Art Reports" and it is recommended to the member countries to implement these reports in their lighting practice. The recommendations are to be considered as a model for the member countries to develop their own national recommendations or if applicable, their own standards. As an example, the comparison of the road lighting recommendations in most of the European countries reveals many similarities.

## Normalization INSTITUTES

**Table 2**

| | | organisation | norm/standard |
|---|---|---|---|
| world | | ISO | ISO |
| regional | Europe | CEN | CEN |
| national | USA | ANSI | ANSI |
| | NL | NNI | NEN |
| | B | IBN | |
| | D | DIN | |
| | F | AFNOR | |
| | GB | BSI | |
| | ... | ... | |
| | ... | ... | |

Table 2 gives a few of the Normalization Institutes.
Here is an example of the different meaning of the word "standard". The International Standardisation Institute, the ISO, is the world-wide organisation on normalization. However, the status of the ISO Standards is not mandatory in the member countries.
This is different for the CEN, the "Comité Européen de Normalisation". The member countries are obliged to implement the European norms. Only national norms which are more strict or have supplementary requirements may exist next to European norms. In many countries norms only become standards if they are referred to in provisions of law.

The Illuminating Engineering Societies and Normalization Institutes do not work separately. In the autumn of 1989 it was agreed between ISO and CIE, that the CIE is appointed as the international body to provide the international norms for lighting. It will be clear, that similar cooperation can be found at a national level.
One more international organisation has to be mentioned. This is the International Electrotechnical Commission. This organisation issues industry standards on, amongst others, lighting equipment. These standards ensure exchangeability of equivalent lamps of different brands, minimum standards of safety and minimal photometric performance.

In a paper called "Minimum efficiency standards for fluorescent and incandescent lamps", Steven Nadel et al.[2] give efficiencies for the light-sources mentioned in the title. A comparison between this paper and IEC publication 81[3] shows, that the authors have higher demands than the IEC. The differences however may not be so big as they seem at first glance, because Steven Nadel and his coauthors refer to the modern tri-phosphor fluorescent lamps, whereas the IEC allows for the halophosphate lamps as well.
One conclusion of the authors is of great importance and promising for the future:
"The economic analysis showed that the highest levels of efficiency available are nearly always the most cost effective".
This conclusion can be translated as follows, "Economic considerations work into the direction of efficient use of energy". Seen in this light, the question can be asked: "Are Energy-Efficiency Standards really necessary?"

## ENERGY-EFFICIENCY AND RECOMMENDATIONS

Considering lighting recommendations once more.
Is the idea of energy-effective lighting influencing the recommendations? As an example, the development of the Dutch recommendations for road lighting will show this. One issue of these recommendations was published just before the energy problems of the seventies. At that moment the committee was composed of representatives of road authorities at the national, regional and municipal level as well as representatives of the lighting industry. This seems to be well balanced, but it wasn't and it didn't work. The energy crisis was the reason for the foundation of the SVEN, the Dutch institution for advice on energy conservation. This institution was sponsored by the Dutch ministry of economic affairs.
The SVEN published its own set of recommendations for road lighting, however generally based on the same quality criteria as in the CIE recommendations, lower levels of quality were published than quoted in both the Dutch and the CIE recommendations. As a result the SVEN recommendations and the recommendations of the Dutch road lighting committee were competing with each other as did the Dutch Illuminating Engineering Society and the SVEN. This confusing and frustrating situation has caused poor lighting installations, which in their turn even caused local political problems.

The solution, though only found at a late stage was simple: Cooperate. The Dutch national road lighting committee now is extended with representatives of the NOVEM, the Dutch foundation for energy and environment in which the SVEN was incorporated.

The recently published recommendations for road lighting in the Netherlands [4] reflect this cooperation. For good understanding it must be kept in mind, that these recommendations do not have a mandatory status. The word "normal-ization" has to be used here. Normalization however is not equivalent to uniformness and with this in mind the recommendations have been developed.

Public Lighting has to support the function of the public areas. These areas have either a traffic function, a residential function (or are areas to which people pay shorter or longer visits) or a combination of these. In the first case traffic safety has the highest priority whereas in the second case, personal security has the highest priority and in the last case both may prevail. In the latter situation, the most severe requirements determine the necessary lighting quality.

Traffic safety is related to a number of measurable quantities, like the dimensions of the road, the number of discontinuities and the composition and density of traffic. Unlike in the German Recommendations for road lighting the concept of traffic density has not been expressed numerically. The judgement of the local authorities and police is determining.

These characteristics are used as input in Table 3. In this table the civil engineering aspect of the road are found at the left hand side columns whereas the traffic characteristics are found at the lines at the top right hand side. This ensures , that the lighting quality chosen reflects the local perception of the road. The output of the table is a lighting quality class. The lighting quality classes are explained in Table 4 in terms of average road surface luminance and luminance uniformity.
As traffic density is one of the determining parameters, full credit can be given to dimming during the hours of low traffic.

**Table 3.** Selection table for lighting classes

| dual carriage-way with central reserve | width of carriage way | crossings level | one way traffic | parking allowed | fast motorized traffic only: traffic density high | fast motorized traffic only: norm. | fast motorized traffic only: low | mixed traffic (excl. bicycles and mopeds): traffic density high | mixed traffic: norm. | mixed traffic: low | all traffic: traffic density high | all traffic: norm. | all traffic: low |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| yes | ... | no | ... | no | 3A | 4A | 5A | # | # | # | # | # | # |
| | | yes | ... | no | 2A | 2A | 3A | 2A | 2A | 3A | 2A | 2A | 3A |
| | | | | yes | # | # | # | 1A | 2A | 3A | 1A | 2A | 3A |
| no | wide (approx. 10 m to 14 m) | yes | no | no | 2A | 3A | 3A | 2A | 2A | 3A | 1A | 2A | 3A |
| | | | | yes | # | # | # | 1A | 2A | 3A | 1A | 2A | 3A |
| | | | yes | no | 2B | 3B | 3B | 2B | 2B | 3B | 1B | 2B | 3B |
| | | | | yes | # | # | # | 1B | 2B | 3B | 1B | 2B | 3B |
| | normal (approx. 7 m to 8 m) | yes | no | no | 3B | 4B | 4B | 2B | 3B | 4B | 2B | 3B | 3B |
| | | | | yes | # | # | # | 2B | 3B | 4B | 2B | 2B | 3B |
| | | | yes | no | 3C | 4C | 4C | 2C | 3C | 4C | 2C | 3C | 3C |
| | | | | yes | # | # | # | 2C | 3C | 4C | 2C | 2C | 3C |
| | narrow (approx. 5 m to 6 m) | yes | no | no | 3C | 4C | 4C | 2C | 3C | 4C | 2C | 3C | 3C |
| | | | yes | no | 3C | 4C | 5C | 3C | 4C | 5C | 3C | 3C | 4C |
| | | | | yes | # | # | # | 2C | 2C | 3C | 2C | 2C | 3C |

\# = situation rarely/never existing
... = not applicable

**Table 4.** Explanation of the lighting classes

| Lighting class: number | $L_{av}$ ($cd/m^2$) = | character | $U_0$ ≥ | $U_1$ ≥ | TI (%) ≤ |
|---|---|---|---|---|---|
| 1 | 2,0 | A | 0,4 | 0,7 | 10 |
| 2 | 1,5 | B | 0,4 | 0,6 | 15 |
| 3 | 1,0 | C | 0,3 | 0,5 | 20 |
| 4 | 0,7 | | | | |
| 5 | 0,5 | | | | |
| 6 | 0,3 | | | | |
| 7 | 0,2 | | | | |
| | | Z | Orientation | | |

Table 3 shows how the recommendations are structured. In the first place words as "residential street", "thoroughfare", "main road", "collector road", "motorway" etc. are not used any more. These terms often lead to misinterpretation and confusion.

Similar considerations hold for the perception of public security. This will result in the fact that residential streets in peaceful villages need a lower lighting quality than residential streets in towns with high rates of crime. In both cases, the lighting installation perfectly serves it purposes. In the older recommendations a uniform lighting quality was required for both the peaceful village as for the "cities of crime" and this lighting quality was related to the latter. The new design of the recommendation make a distinction between these different situations and therefore not more than only the minimal necessary energy is used for public lighting.

Finally, attention is paid to the maintenance of the installation. This means, that the recommendations imply the use of modern equipment with low depreciation which also has a favourable effect on the energy necessary to run the installation.

This example from the professional lighting world shows, that for professional lighting installations considerations about energy-efficiency are well implemented.
In the field of domestic lighting this is not the case. Here we have to deal with a simple psychological problem. If a lay-person has the choice of buying a simple incandescent lamp at a low price or a modern energy-saving lamp at a much higher price, his or her choice is almost evident.

## CONCLUSIONS

1) lighting cannot be considered as an independent entity. It must be considered in relation to its function and environment.
2) In Europe in contrast to the U.S.A., no energy-efficiency standards for lighting exist.
3) In the field of professional lighting, expert committees, provided that they have the correct composition, already produce lighting recommendations which enable careful use of energy
4) In the non-professional lighting field much effort has to be put in education as to achieve a wide acceptance of energy effective light-sources.

Final remark.
Standards as such only can avoid excessive use of energy but to reach the goal of really efficient use of energy, much more has to be done.

## REFERENCES

[1] CIE Roster February 1990, Central Bureau of the CIE, Wien Austria
[2] Steven Nadel, Howard Geller, Fred Davis and David Goldstein. "Minimum efficiency standards for fluorescent and incandescent lamps". Page 9. Personal communication from Evan Mills.
[3] IEC Publication 81. "Tubular Fluorescent Lamps for General Lighting Service"
[4] Marie J. G. de Man. "Nieuwe aanbevelingen voor Openbare Verlichting in Nederland - een voorpublicatie." (in Dutch) Elektrotechniek 11/67 November 1989 page 983 - 987