Proposal for a shared model of Energy Certification for lighting devices and installations for Public Lighting

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1. Premise

In December 2008, the European Community reached an agreement on the climate and energy package called "20-20-20": this program foresees, by 2020, a 20% reduction in greenhouse gases, a 20% increase in energy efficiency and the achievement of a quota of 20% of energy production from alternative sources. Furthermore, growing concern regarding the consumption of energy deriving from the use of electrical and lighting devices has been illustrated for example by **regulations n. 244/2009/CE and n. 245/2009/CE**, which define the specifications for the eco-compatible design of lamps.

These measures stem from the **EuP directive 2005/32/CE** on the promotion of eco-design activities for *Energy Using Products*, and have the purpose of integrating environmental considerations during the design phase, in accordance with the principles of the IPP (*Integrated Product Policy*) strategy. The IPP approach is based on: consideration of the useful life cycle, collaboration with the market (with the use of incentives), involvement of the interested parties, continuous improvement and multiplicity of the instruments of intervention.

In accordance with what is defined above and in the context of energy saving and environmental sustainability, HERA Luce proposes a series of strategies connected with the adoption of "the best techniques available" on the market (or BAT, acronym of *Best Available Technologies*) which, as defined in the **96/61/EC directive,** later abrogated by the **2008/1/EC directive**, are "the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent, and where this is not practicable, generally to reduce emissions and the impact on the environment as a whole".

At this time, it is necessary to promote an energy and environmental *Benchmarking* linked to Public Lighting; *Benchmarking* is defined as a systematic, continuous process of comparison among the performances of organizations, functions and processes with respect to the examples of excellence on the international level, not only in order to equal these levels of performance but to surpass them. This activity, fundamental for guaranteeing adequate strategy management, develops in two dimensions: the first, the measurement of efficiency (by means of the parameters indicated in the proposed sheets) and the second, that of identifying the *Best Practices* (which will be discussed with the manufacturers so as to increase the efficiency of luminaires and installations).

To achieve this, as part of the work done on researching and improving Public Lighting systems, I have developed two different certification models for HERA Luce, one referring to lighting devices and the other to lighting installations, which define an energy class of comparison in relation to the technical regulations in force and the performance requirements defined on the basis of the *Best Available Technologies*.

In order to ensure optimal management of Public Lighting installations, one of the challenges of the immediate future is that of succeeding in implementing environmental principles within the Public Administration sector: using their buying power to select goods and services that also respect the environment will allow them to contribute considerably towards achieving sustainable development.

The *Green Procurement* initiatives are one of the market responses to the sustainability challenge: in these cases preference is given to the goods that are “environmentally preferable”, in that they impact less than other goods of the same kind; on the basis of these indications, the **2004/17/EC** and **2004/18/EC directives** on tenders explicitly allow the judging boards to choose specifications based on technical norms or on performance-linked requirements.

These certificates can foster a virtuous circle to involve the Administrations, Managers and Manufacturers so that *Green Public Procurement* initiatives can also be implemented in Public Lighting.

This document **is designed solely for technical lighting engineering applications for exteriors** and thus for all that commonly falls under the heading “public lighting”, comprising the objects used to light those public areas for which the local council is responsible and therefore roads, parks, gardens, etc.

2. The advantages of introducing energy efficiency criteria

Until little more than ten years ago, the lighting technology market offered few types of lighting devices, with price ranges mainly determined by the materials used or by the greater or lesser profit margin established by the individual manufacturers, on the basis of their brand prestige.

Subsequently, even before the introduction of LED technology, the market was undermined by the appearance of products of debatable quality and by the increasing lack of transparency obtainable from manufacturers and associations (in addition to more aggressive strategies, another contributory cause can be found in the issue of new fundamentally different regional and national laws, often with no uniformity).

For these reasons, **the choice of a lighting product, that once could be based on a minimum of shared knowledge, today must be guided by specific technical parameters.**

The introduction of new technologies has further worsened the situation: on the one hand, manufacturers historically unconnected with the lighting engineering sector and often unqualified have appeared on the market, and on the other, the parameters of evaluation and the know-how necessary have increased exponentially.

In addition, recent times have seen the appearance in the newspapers or on the web of announcements regarding the amazing immediate savings to be made thanks to the introduction of latest generation technology; all this is fuelled by the economic squeeze to which public Administrations are subject, leading them to hope for a miraculous solution that will be able to revive their finances.

Any technology, however, will present merits and defects and, naturally, it will be difficult for technological evolution to make it possible to save so much in such a short time. Furthermore economic evaluations cannot be made outside context: every lighting installation is an individual case and therefore it would be wise to always compare the best technology available today with the current situation (it is also obvious that any renovation of an installation that was oversized and badly designed will lead to savings, regardless of the solution employed).

Moreover it is essential to go into the specific economics of each proposal: it is difficult to understand that **an installation present on the territory is a sunk cost and therefore is not relevant in reaching a rational decision; the decisions must be taken solely on the comparison between the new technology available and the possible returns of this investment.**

George Akerlof (Nobel prize for economics in 2001), in his article *"The markets of lemon: quality uncertainty and the market mechanism"*, describes how the interaction between quality heterogeneity of the products offered and asymmetric information possessed by the buyer and seller (i.e. when one side has more information that the other and can gain advantage from this situation) can lead to the disappearance of a market.

In the situation described, assuming that the quality of the products cannot be evaluated by the buyer (because of the asymmetric information), the vendor is encouraged to propose goods of low quality passing them off as high quality goods. The buyer, on the other hand, takes the vendor's behavior into consideration and presumes the quality of the goods to be uncertain. Only the average quality of the goods will be evaluated. This means that **all those goods whose quality is above average will be excluded from the market**. This behavior is repeated until a no-trade equilibrium is reached.

The consequence of the mechanism described in the article is that the markets, in the situation in which quality is an uncertainty, cease to exist altogether. Examples of this are found in the second-hand car market, the lack of formal credit markets in developing countries and the difficulty for the elderly to obtain health insurance (in the absence of government programs).

One of the main dangers in the public lighting market lies in the total absence of performance controls. In general, the buyers, with incomplete information, are contractually weak, and therefore the norms should protect them making it illegal to sell products of poor quality or to use deceptive advertising. Until today there are no norms of this type and, in addition, many standard programs only use an evaluation between high and low quality, even though quality varies continually: these standards encourage the production of goods that present the lowest possible quality (and relative production costs) or else the lowest level of quality required to obtain the highest evaluation.

The method we propose, on a voluntary basis, is therefore aimed at eliminating this asymmetry, and is to all effects an "energy certificate", that is to say certification that establishes the absolute value of the efficiency level of the examined system, based on objective parameters, linked to the characteristics of the individual components, independently of the contingent situations in which they may be found.

Historically, the national programs of ecological labeling developed following the oil crises of the '70s so as to restrict the uncontrolled spread of "self-certified" energy trade marks and also to facilitate the diffusion of correct information to the consumers; the first forms of energy efficiency labeling were introduced in Canada, the United States and Europe (with the **79/530/EEC directive**) for household appliances and then spread throughout the rest of the world.

Subsequently, with the **92/75/EEC directive,** Europe saw the introduction of a mandatory System of Energy Labeling able to supply information on energy consumption and on the essential resources used, in addition to complementary information linked to the operation of the equipment itself. At the same time in the United States, they created an Energy Efficiency Mark, among the most important internationally, the Energy Star Program, which was applicable to computers and monitors.

At the beginning of the '90s, the European Union focused its attention on adopting a label for certifying the ecological quality of products, known as Ecolabel, which was a voluntary system of Type 1 Environmental Labeling. Recently the energy labeling reference scenario has been enriched with further initiatives, involving not only the household appliances and Information & Communication Technology sectors, but also the building sector. After the various "pilot" voluntary certification programs, such as the "Building System" mark put forward in 2004 by the Certification and Quality Mark Institute and the mandatory certification initiative "Climate House" (Casa Clima) from the independent Province of Bolzano, energy certification of buildings has become obligatory in accordance with the **D.lgs. 192/2005** law (modified and integrated by the **D.lgs. 311/2006** law), which have been supplemented by local norms which – as part of the broader spectrum of national law – foresee the evaluation of the energy behavior of buildings, both for new constructions and for building redevelopments.

The introduction of energy criteria into the real estate market, in a period of economic crisis, is a valid example of how such principles can favor the recovery of a sector in difficulty and characterize the most recent development initiatives: beyond the undeniable advantages for the environment and livability, bio-construction also offers numerous opportunities for re-launching the market. Furthermore it guarantees lower consumption and reduced maintenance costs and therefore greater performance efficiency, not to mention the prerequisites for consolidating the quality levels of life.

As in the building sector, energy certification in other sectors is identifying that surplus value that may turn out to be decisive for the qualification and promotion of future manufacturers.

Unfortunately, still today, the benefits of energy efficiency are restricted by several barriers that limit their diffusion.

The first of these is the difficulty for the final user to keep up with technological evolution or, at least, to be able to adequately evaluate the differences between the different technologies available; this leads him to direct his attention towards certain choices which are fundamentally not efficient. Consequently, the final user, distracted by other evaluation elements, is unaware of how much he consumes and how much he could save from the energy and financial points of view.

The second barrier is the non-economic rationale of the consumer: despite the theory that the rational consumer chooses the product that costs less over the entire life cycle, various surveys have shown that he hardly ever carries out a calculation of this type and therefore the purchase is determined by momentary short-term impressions. In addition to this, it is difficult for manufacturers to justify the extra costs created by more efficient technologies, and these are therefore shelved even before the effective costs and advantages are evaluated.

Another barrier is the lack of training of the technicians, which is sometimes combined with professional inertia: while the European community is moving towards the analysis of the Life Cycle Cost of the various products, the design is still centered around empirical methods and consolidated procedures rather than on the legislative and technological evolution in the various sectors.

Italian legislation includes a series of specific instruments - energy Certification, energy service Contracts, White Certificates, the Energy Bill (Conto energia) for photovoltaic energy, Escos (Energy Service Companies) – established to promote improvements in energy efficiency, but improper use or delays in their application hinder the full achievement of these interventions, which are slow or wholly prevented.

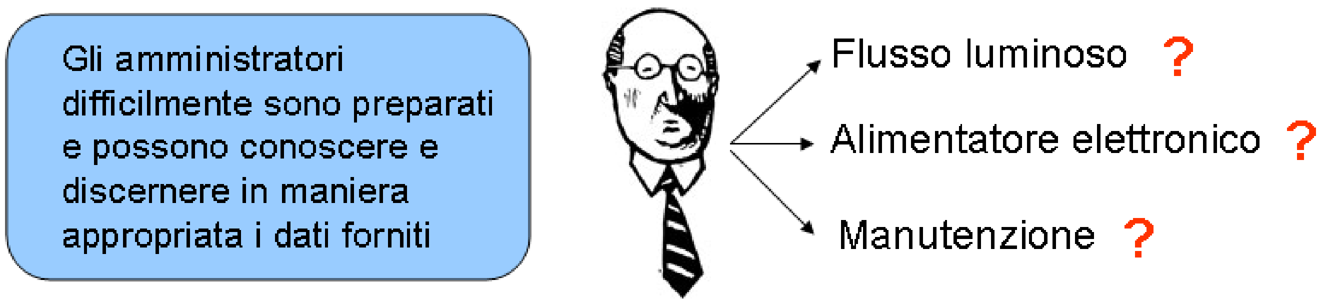
The diffusion of energy efficiency criteria must therefore represent a constant commitment, in order to guarantee that this type of procedure penetrates all fields.

Given the importance and economic weight that Public Lighting holds in public balance sheets, it seems to be a matter of the utmost urgency to define criteria also for this sector to help guide public Administrations in the choice of the most efficient systems and thus towards purchasing and redevelopment according to *Benchmarking* tenets.

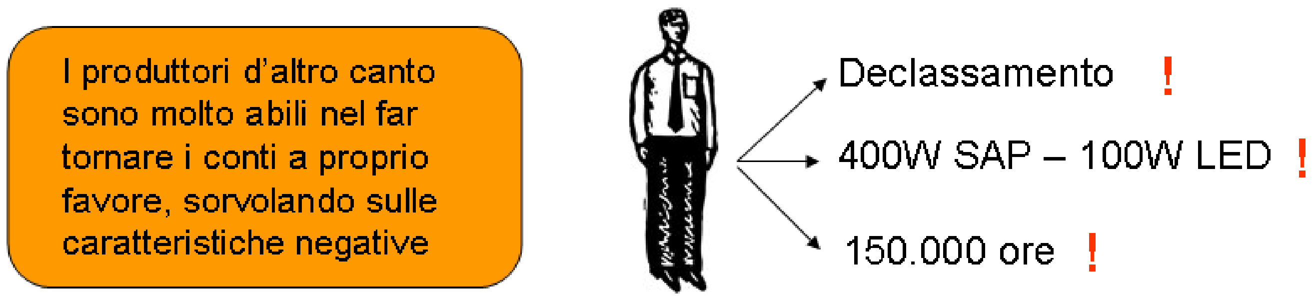
3. Objectives and assessments for adopting energy criteria in P.I.

The recent economic crisis and the rise in energy costs have brought to light serious structural problems affecting the Public Lighting sector: until today, purchasing procedures have not always aimed towards improving existing installations and saving energy; in addition the new installations are designed more to respond to subjective taste than to serious consideration of the real lighting requirements.

To further complicate the situation, there is insufficient accurate information at the Administrators' disposal and, since their position does not require them to have the scientific prowess to deal with technical matters, they are unable to appropriately interpret the data supplied by the various manufacturers: it is therefore relatively easy to sell products that are non-competitive on the market level, by playing on their perplexities.



In the same way, often, the manufacturers of lighting devices (especially those without a solid background in the public lighting sector) do nothing to facilitate the layman's choice; moreover they sometimes present data that are difficult to understand and verify, if not intentionally exaggerated.



This state of affairs results in extreme uncertainty in the choice of new public lighting installations and redevelopment strategies for existing systems: what should be a field regulated by strict energy analysis and lighting engineering calculations, dictated by cogent legislation on the subject, is often handled superficially.

In order to deal with the urgent need for a clear, common outline of the principles that can regulate the Public Lighting sector, HERA Luce – with the advantage of being constantly in contact with the situation in the sector – therefore plans, by means of the proposed energy certificates, to achieve the following objectives:

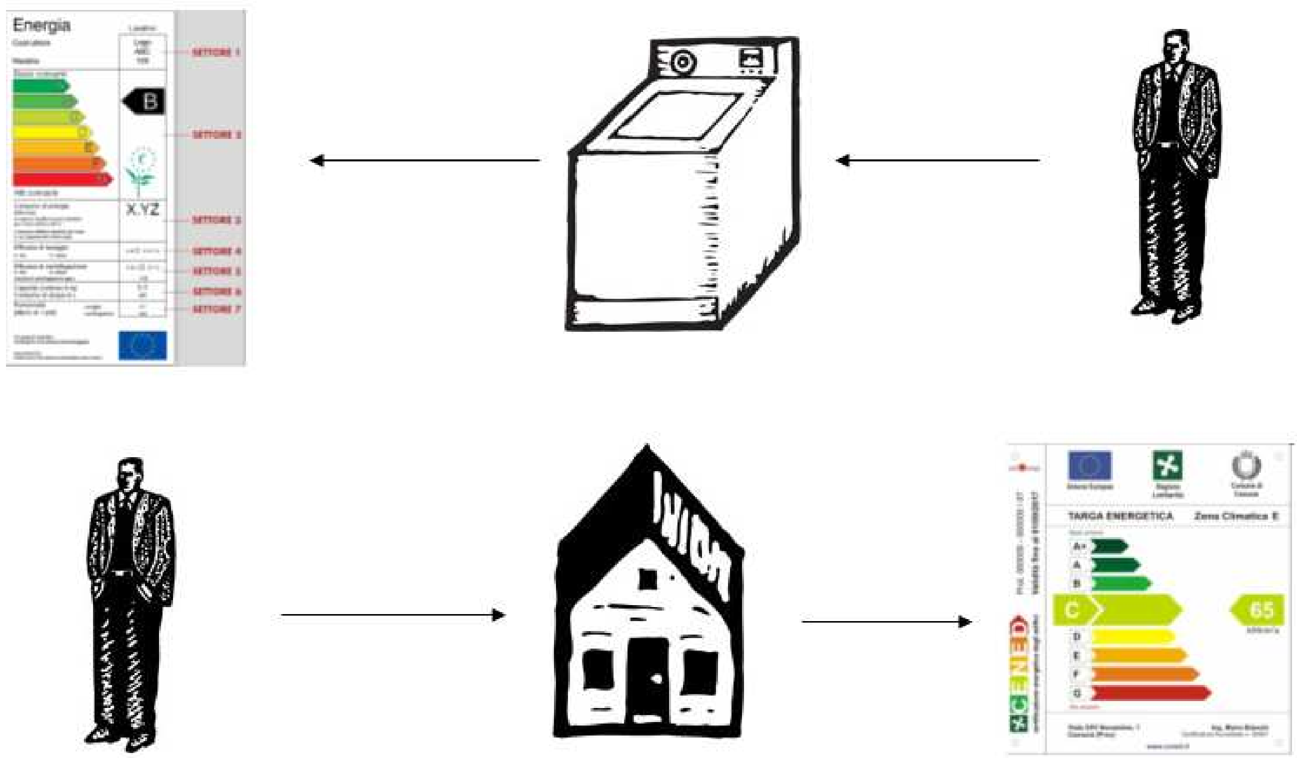
- "translation" of technical data and thus the quality criteria relating to a Public Lighting installation into easy-to-read pointers;
- endowment of the products with better features since they often do not closely respond to market expectations today, due to lack of information;
- promotion, with an eye towards *Green Public Procurement* on behalf of Public Administration, of optimal lighting systems in the energy, economic and technological ambits thus discouraging poor quality products;
- provision of a useful and practical tool, able to help technicians in an extremely specific environment, as is that of Public Lighting.

The fundamental question at this point is: "How can these needs be met simply and effectively?".
The idea of introducing energy criteria in the Public Lighting sector came to me when I found myself needing to buy new domestic appliances for my home: I am not very expert in household matters and therefore the comparison parameters I was able to implement thanks to my experience were limited; in this situation therefore I found the energy certificates supplied with the various appliances a great help.
These certificates not only instantly illustrated the consumption (by means of the already familiar mechanism of letters and colors), but also supplied numerous indications regarding operation and use.
To answer the question therefore we will take two examples from everyday life, which can immediately illustrate our aims (*Rem tene, verba sequentur*).

We would like to buy a new washing machine and we have never been very good at doing the washing, nor do we have extensive knowledge of the various products on the market; at first glance, all the washing machines look more or less the same, and the sales assistant, playing on the buyer's lack of expertise, can easily "push" us to buy one product rather than another for his own convenience.
In this case, help can come from the energy labels whose simple indications can give a broad evaluation of performance and thus the first indication of whether the purchase is good or not (obviously it is clear that, prices being equal, a rational customer will normally prefer a product with a higher energy class; or that a higher energy class will justifiably command a higher price).
Certification however is an important instrument at the service of the consumer, who can get an immediate overview of the efficiency of the product and this enables him to make his comparison of the various products on offer on a concrete basis.

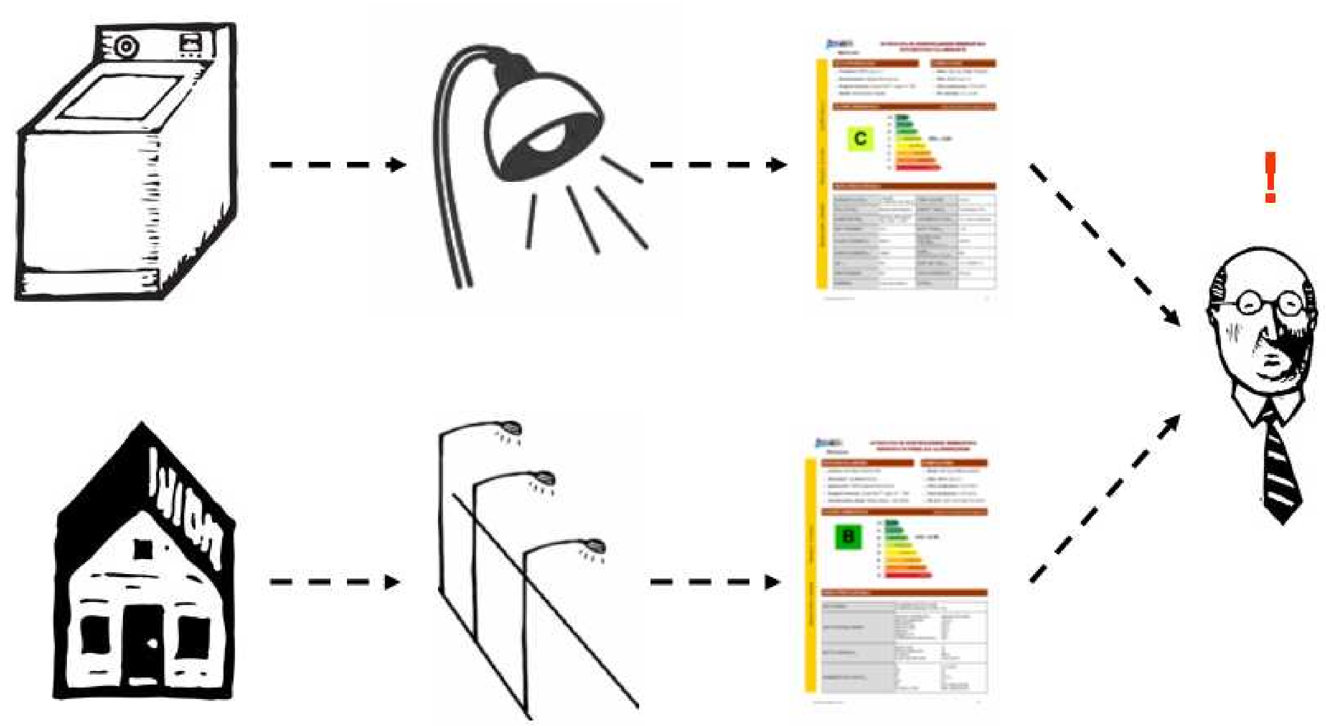
The second example regards the purchase of a property: we all know that the expense is unfortunately not only that of the purchase, but also regards the maintenance and above all the use of water, gas and electricity; in the last few years, the property energy certification program has been designed to highlight the probable future consumption bills and thus to forecast the energy efficiency of a building. Obviously the choice of the property is mainly linked to other factors (such as position or cost), but the supply of indications on "energy" costs certainly encourages the purchase of buildings with better performance, built with the best technologies, thus triggering a virtuous circle of *benchmarking* on the energy efficiency.

Also, in this case, the properties of a building, determined by its structural components (outside walls, windows, ceilings, etc..) and installations (heating and cooling installations) as well as its layout, are expressed in a clear fact sheet that anyone can decipher.



On the basis of these considerations, I have proposed two different types of certificates, which can be linked to what we have read above: just like for a household appliance, it is possible to supply a broad indication of consumption and performance of a lighting device by means of an indication of its efficiency; just like for a building, a lighting installation can be accompanied by a document which certifies consumption and operation specifications.

These certificates are independent of the technology used (thanks to a method of comparison based on parameters derived from the *Best Practices* today available in the public lighting field) and therefore can also supply a useful yardstick in the case of recently introduced technologies, such as LED light sources, which are difficult to compare with traditional technologies except in this way.

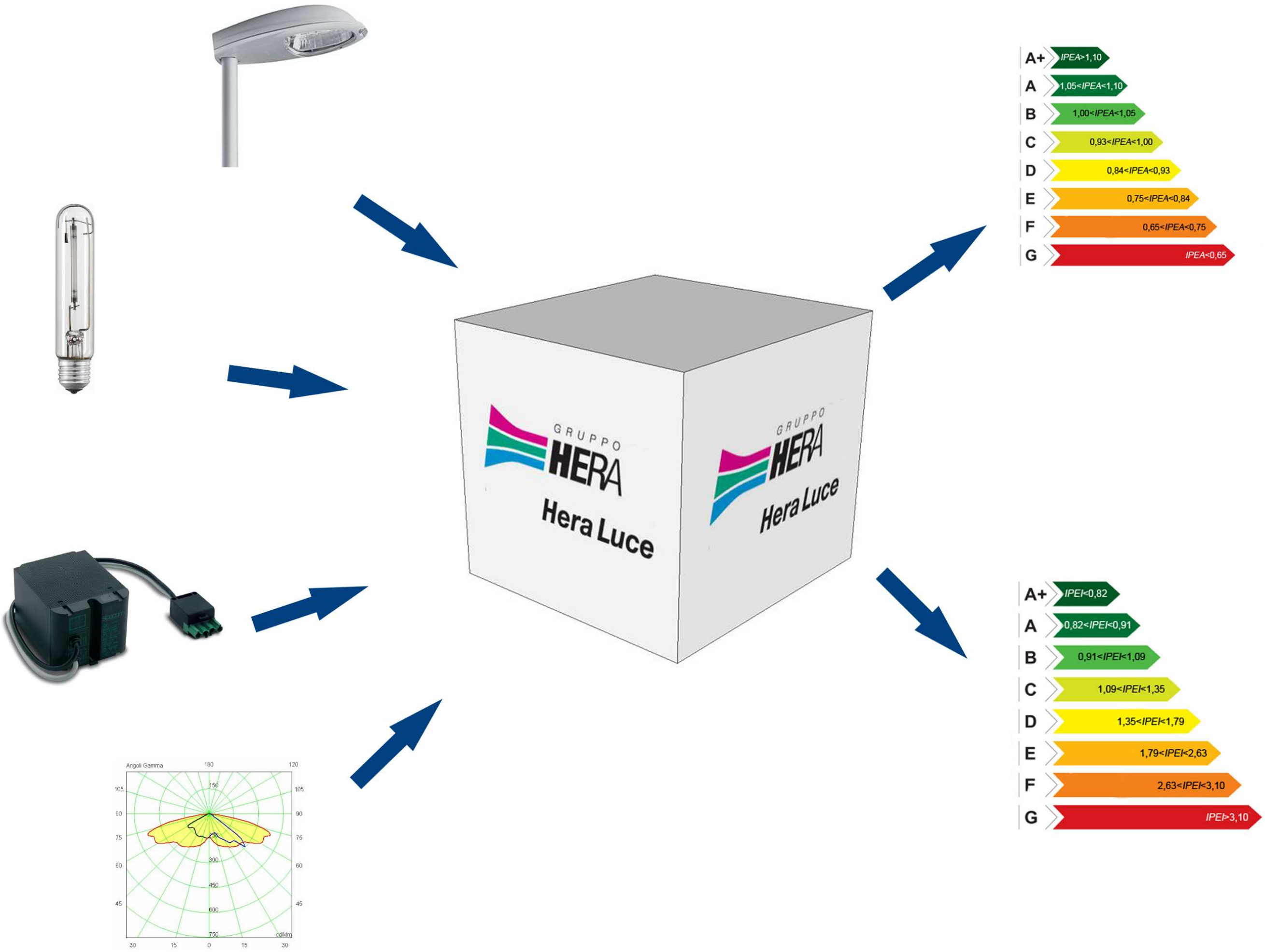


Thus **technical information is “translated” into easy-to-read pointers that allow the current state of an installation and the possibility of improvement to be instantly defined**: therefore it would be difficult for example to show how an installation built according to the book (for example in class A) could allow wide margins for improvement; in the same way a poor installation (for example in class E) could be improved using different types of intervention, proportionately with the investments made.

Finally it should be remembered that, as for every product on the market, the risk remains that the data supplied may not be completely reliable: for this reason HERA Luce offers their services as intermediary between institutions and manufacturers, as guarantors of the lighting systems presented.
Thanks to free shared certification, the manufacturers can guard against any accusation of altering results, while the Public Administrations have the guarantee of those handling the installation and can therefore be rely on the expected savings.

Our certification mechanism gives the users full information at no cost on the relative quality of the lighting devices and installations for public lighting, without in any way limiting the goods available or preventing the sale of inferior products.

The system is fully automatic and works by “extracting” the data already available and transforming them into the characteristic letters that distinguish certifications.



In the future it will be possible to insert our classification system in a software that, in addition to effecting lighting engineering calculations, will be able to automatically include the calculation of the energy indices.

Although this is a voluntary tool which is unable to prevent certain products being put on the market, in the long term it could keep at bay the lowest quality products (today, for example, fridges for the home are no longer produced in classes D or E), and in addition **supply useful signals to the Public Administrations with regard to the greater or lesser desirability of certain solutions**.

4. Description of the energy criteria used

As illustrated in the previous chapter, energy criteria can be divided into two large sectors: the first concerns the individual lighting device, the second deals with the whole lighting installation.

As far as the individual lighting device is concerned, we have chosen to make direct reference to the main components which contribute towards defining its efficiency: the light source, the optical component, the power supply; in this way an initial evaluation can be had, not directly referring to a particular installation, but is some way regarding the "global" operation of the lighting device.

As far as lighting installations are concerned however, reference is made both to the lighting device installed, and to the characteristics of the surroundings that define the geometry of the installation (such as the inter-axis between the light points and the width of the road): in this way it is possible to intuitively determine the best or worst use of the energy resources according to the illumination required by Italian regulations.

In both cases, the efficiency value is determined as the ratio between the calculated yield value and the reference parameter (determined on the basis of standard classes of installations or lighting devices, based on the average *BAT* to be found today): in both cases a class "C" corresponds to "average" luminaires or installations present today on the territory, while a class "A" defines the excellent categories of *BAT* to be found today.

Calculations are made solely on the basis of parameters that are by now consolidated, defined by specific norms and that already today are used to define the technical characteristics of a lighting product (for example the nominal efficacy of a light source or the efficiency of a ballast); the work performed has been that of linking these parameters with the *Best Available Technologies* that today define the lighting market.

We would like to underline that the document we are presenting is therefore, to all effects, an **"energy certificate"**, or **a certification of the absolute value of the efficiency level of the system examined** which is based therefore on objective parameters that are linked to the characteristics of the individual components, independently of the contingent situations in which these may be found. In this way it is possible to directly compare different types of installations and to obtain immediate verification of their quality.

Moreover, differently from other parameters found in the literature, our criterion is based on the **direct comparison** between calculated and reference values: this allows the calculated values to be gauged on the basis of the various possible applications (whether they refer to the operation of a lighting device or to the lighting engineering categories of an installation), without running the risk of having general and non-contextualized parameters.

4.1 Global efficiency of a lighting device

Given the multitude of road lighting devices on the market today and the extreme disparity of sources available, it would appear necessary to review the factors that are used today to express the performance and energy characteristics.

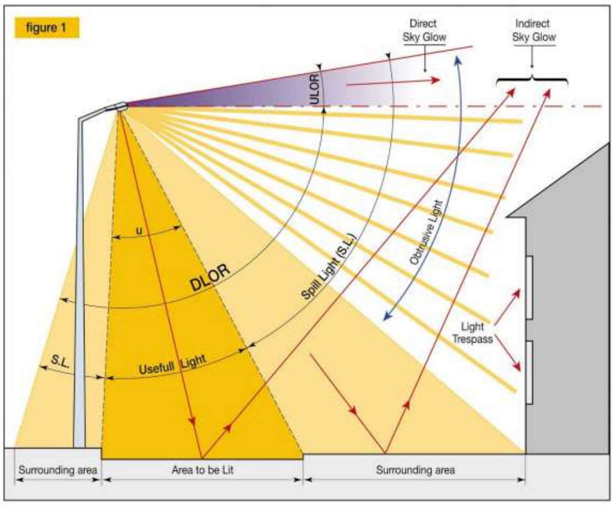
Moreover, very often Public Administrations do not base their evaluations on existing installations; for example, **in the terms of contract, the minimum requisites of the lighting device are given, without obviously mentioning the performance that this should give in the individual applications**. For this reason an initial evaluation index has to give indications regarding the performance guaranteed by the device, independently of the way it is installed. It is also true that even the best device in the world, if used badly, will give bad light (but this factor is taken into consideration by our second indicator, relating to the installation).

The first coefficient we propose is therefore designed to clarify what “is inside” the device and thus whether the components used are of top quality and, consequently, efficient or not; the correct use is then entrusted to the lighting engineering designer, whose job it is (or at least should be) to exploit the different types of devices available to their best advantage.

To achieve the least possible consumption of resources and maximize results, it is important to take into account all the variables that contribute towards the good functioning of a lighting device; factors such as the luminaire yield and luminous efficacy of the lamps only illustrate partial characteristics and are incomplete.

In particular the luminaire yield (calculated as the ratio between the luminous flux emitted by the luminaire and the flux originally emitted by the naked lamps present in it) does not take into account the possible dispersion of luminous flux upwards (and therefore not used to illuminate the road surface) and of the power absorbed by the luminaire.

The luminous efficacy of the lamps (calculated as the ratio between the luminous flux emitted by the lamp and the electrical power consumed) is instead generally a nominal efficacy, that therefore does not take into account the real power absorbed by the other components inside the luminaire and in addition does not give indications on the flux dispersed due to internal reflections, lenses, etc.



For this reason it was decided to incorporate these two factors in a global coefficient that takes into account the useful light emitted by the luminaire (and thus directed towards the road area) and the real power absorbed by the luminaire (inclusive therefore of the lamp and other components such as ballast, starter, etc.).

This coefficient also accounts for the real physical meaning of efficiency, meaning the ratio between work performed by a system and the energy supplied to the system (even though in this specific case power rather than energy was taken into account; all the parameters taken as reference are linked solely to intrinsic characteristics of the road lighting (i.e. they are independent of the installation that is to be set up and are therefore only linked with the components inside it).

For further reference regarding terms and definitions, please refer to the norm **UNI EN 12665:2004 - "Light and lighting – Basic terms and criteria for specifying lighting requirements"**.

Definition

The **global efficiency of a lighting device** is defined as the ratio:

$$\eta_a = \frac{\Phi_{sorgente} \cdot BLF \cdot Dlor}{P_{reale}} = \frac{\Phi_{sorgente} \cdot BLF \cdot Dlor}{P_{sorgente} / \eta_b} = \eta_{sorgente} \cdot \eta_b \cdot BLF \cdot Dlor = [lm/W]^{1,2}$$

in which are defined:

$F_{sorgente}$: The nominal luminous flux emitted by the naked sources present in the luminaire, expressed in lumen, measured in standard conditions (generally at 25℃ ambient t emperature and controlled power supply);
please refer to the norms **CEI EN 60357:2006, EN A1:2008 and EN A2:2008** (halogen lamps), **CEI EN 60081:2001, EN A1:2002, EN A2:2003 and EN A3:2005** (double capped fluorescent lamps), **CEI EN 60901:2004, V1:2005 and V2:2008** (single capped fluorescent lamps), **CEI EN 60188:2002** (high pressure mercury vapor lamps), **CEI EN 60192:2002** (low pressure sodium vapor lamps), **CEI EN 60662:2001** (high pressure sodium vapor lamps), **CEI EN 61167:1998 and V1:1999** (metal halide lamps).

BLF : The *BLF* (*Ballast Lumen Factor*) factor is defined as the ratio between the lumens emitted by the system considered (ballast effectively installed with reference lamp) and the lumens emitted by the reference system (reference ballast with reference lamp), according to the formula *BLF = Lt/Lr*, in which *Lt* is the flux emitted (expressed in lumen) by the reference lamp when this is connected to the effectively installed ballast and *Lr* is the flux emitted (expressed in lumen) by the reference lamp when this is connected to the reference ballast. For the definitions and methods of measurement please refer to the norms **EN 61347** or **EN 50294**.

Dlor[3] : The ratio between the luminous flux emitted by the luminaire directed to the downward hemisphere and the luminous flux originally emitted by the naked lamps present in it and operating with the same power supply

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[1] As reference parameter please refer to the proposal followed by the commission of CE M226 and CELMA "Proposal for luminaire efficiency factor presentation" CEN TC 169 document N418,2001 for the introduction of efficiency parameter (Luminaire Efficiency Factor) for interior lighting defined as:

$$LEF = \frac{Lor \cdot \Phi_{lamp}}{W_{reali}}$$

See also NEMA Standards Publication No. LE5, where the efficacy parameter of a luminaire (Luminaire Efficacy Rating) is defined as:

$$LER = Lor \cdot \eta_{ballast} \cdot \eta_{lamp}$$

[2] The agreement $W_{reali}=W_{sorgente}/\eta_b$ is only possible when the ballast efficiency considers the whole power supply system (for example, in the case of a ferromagnetic power supply, also the losses related to the condenser and starter in non-active mode are included).

installation (please refer to document **IEC 50 (845/CIE 17.4)**; it must be noted that these measurements are defined for an ambient temperature of 25℃ and under contro lled general power supply.

P_{reale} : The real power absorbed by the luminaire, expressed in Watts, meaning the sum of the power absorbed by the sources and by the components present inside the same (starter, ballast/reactor, condenser, etc…); this power is what the luminaire absorbs from the electricity line during normal operation (therefore inclusive of any luminaire able to absorb electrical power from the mains).

$P_{sorgenti}$: The nominal power of the source, expressed in Watts.

$h_{sorgente}$: The nominal efficacy of the light source, expressed in lm/W, meaning the ratio between the flux emitted by the lamp and the nominal power absorbed by the latter in normal conditions (please see above).

h_b : The ballast efficiency, expressed in percentage, meaning the ratio between the nominal power of the sources and the power entering the lamp-power supply circuit with other possible auxiliary loads (see above and norm **EN 50294**).

In the case of **a LED lighting device**, in relation to the contents of the new norm **UNI 11356-2010**, it is possible to calculate the global efficiency of the luminaire by means of the following formula:

$$\eta_a = \eta_{sistema} \cdot Dlor = \eta_{app} \cdot Dff = [lm/W]$$ [4]

in which are defined:

$h_{sistema}$: Quotient of the luminous flux emitted by the LED module by the electrical power used by the LED module complete with its power supply device, including mechanical components such as, for example, any dissipators, at a specified trial ambient temperature, expressed in lm/W (see norm **UNI 11356:2010**).

Dlor : The ratio between the luminous flux emitted by the luminaire towards the downward hemisphere and the total luminous flux emitted by the LED module present, as indicated above; any dispersion due to the secondary optical systems applied or protective screens is thus deducted from the flux.

h_{app} : Ratio between the luminous flux of the luminaire and the electrical power absorbed by the luminaire, expressed in lm/W (please refer to norm **UNI 11356:2010**).

Dff **:** The percentage of flux emitted by the luminaire towards the lower semi-sphere of the horizon (calculated as the ratio between the direct luminous flux towards the lower semi-sphere and the total luminous flux emitted), i.e. below the angle of 90°.

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[3] On the basis of the norm **UNI EN 13032-1** the factor $Dlor$ can be calculated as:

$$Dlor = Dff \times Lor$$

in which are defined:

Dff : The percentage of flux emitted by the luminaire directed towards the downward semi-sphere of the horizon (calculated as the ratio between the luminous flux directed towards the downward semi-sphere and the total luminous flux emitted), i.e. below the angle of 90°;

Lor : The luminous efficacy of the luminaire (calculated as the ratio between the luminous flux emitted by the luminaire and the luminous flux originally emitted by the naked lamps present in it in standard conditions); please refer to **IEC 50 (845/CIE 17.4)**.

[4] It can be noted how, for a LED luminaire with luminous flux totally directed towards the downward hemisphere, the global efficiency corresponds with the luminous efficacy of the LED lighting device, as defined in **UNI 11365:2010**.

It can be seen that the efficiency formula is reduced to the evaluation of the individual components installed inside the lighting devices (source by means of the $h_{sorgente}$ parameter, ballast by means of the h_b parameter and optical systems by means of the *Dlor* parameter), thus confirming what we said in the introduction.
This parameter therefore does not directly indicate the savings that can be made by adopting a particular lighting device (for this purpose, please refer to the efficiency index of an installation described later), but the potentiality of this product to enable this kind of saving.
Also in the case of LED devices it should be underlined that, within the parameter indicating the luminaire efficiency in accordance with norm **UNI 11356:2010**, auxiliary and power supply components, as well as the efficiency of the LED module, are also evaluated.

Hera Luce has tabled the most common *Dlor* values for traditional luminaires with discharge lamps, some of which are shown in the table below:

Type of road lighting	Visual reference	*Dlor* indication
Transparent globe without optical system		0.30
Transparent globe with modular optical system		0.35
Artistic transparent glass without optical system		0.40
Mushroom without optical system		0.55
Acrylic cup without optical system		0.57
Fixture with aluminum body without shield		0.65
Normal road lighting and flat glass		0.70
Normal road lighting with acrylic cup		0.73
Good road lighting with flat glass		0.80
Good road lighting with transparent cup.		0.83

This is simply a table indicating general reference parameters for lighting devices and cannot cover the considerable baggage of information on luminaires available to HERA Luce; every evaluation has to be carried out with the real parameters of the luminaire in question.

Energy classification

On the basis of what has emerged from the experimental data in our possession and the theoretical evidence specified alongside, for every type of application and nominal power, a **reference global efficiency** is proposed with which to parametrize the global efficiencies related to a lighting device; as regards LED luminaires, the nominal source power refers to the power absorbed by the LED module (i.e. excluding the power supply unit, in accordance with the indications of **UNI 11356:2010**).

a) Lighting for roads and large areas

Nominal source power	$\eta_{sorgente}$ [5]	η_b [6]	*Dlor* [7]	Reference global efficiency (η_r)
W ≤ 55	88	.88	.78	60 lm/W
55 < W ≤ 75	94	.88	.78	65 lm/W
75 < W ≤ 105	107	.90	.78	75 lm/W
105 < W ≤ 155	116	.90	.78	81 lm/W
155 < W ≤ 255	133	.90	.78	93 lm/W
255 < W ≤ 405	141	.90	.78	99 lm/W

b) Lighting for pedestrian and cycling areas

Nominal source power	$\eta_{sorgente}$ [8]	η_b	*Dlor*	Reference global efficiency (η_r)
W ≤ 55	80	.88	.71	50 lm/W
55 < W ≤ 75	90	.88	.71	56 lm/W
75 < W ≤ 105	90	.90	.71	58 lm/W
105 < W ≤ 155	98	.90	.71	63 lm/W
155 < W ≤ 255	105	.90	.71	67 lm/W

[5] Following BAT procedures, in accordance with the **2008/1/EC directive**, for this parameter the efficiency of the best high pressure sodium lamps was taken, respectively 50W super, 70W super, 100W super, 150W super, 250W super, 400W super, available today at market price. Please also refer to the contents of the National Plan of Action (Piano d'Azione Nazionale) on Green Public Procurement (PANGPP) in relation to the minimum environmental criteria for the purchase of HID lamps and LED systems, lighting devices, lighting installations.

[6] For this parameter, reference was made to attachment VII of the **n. 245/2009 regulation** of the European Commission.

[7] Following BAT procedures, in accordance with the **2008/1/EC directive**, for this parameter reference was made to the characteristics of "standard" road lighting present today on the market which can be defined through the specifications in the national lists for electrical works. Please also refer to the contents of the National Plan of Action (Piano d'Azione Nazionale) on Green Public Procurement (PANGPP) in relation to the minimum environmental criteria for the purchase of HID lamps and LED systems, lighting devices, lighting installations.

[8] For this parameter reference was made to table 20 of attachment V of the **n. 245/2009 regulation** of the European Commission relative to improvement criteria for metal halides and lamps.

255 < W ≤ 405	105	.90	.71	67 lm/W

c) Lighting for green areas and parks

Nominal source power	$\eta_{sorgente}$	η_b	*Dlor*	Reference global efficiency (η_r)
W ≤ 55	80	.88	.70	49 lm/W
55 < W ≤ 75	90	.88	.70	55 lm/W
75 < W ≤ 105	90	.90	.70	57 lm/W
105 < W ≤ 155	98	.90	.70	62 lm/W
155 < W ≤ 255	105	.90	.70	66 lm/W
255 < W ≤ 405	105	.90	.70	66 lm/W

d) Lighting of historical city centers with artistic luminaires[9]

Nominal source power	$\eta_{sorgente}$	η_b	*Dlor*	Reference global efficiency (η_r)
W ≤ 55	80	.88	.72	51 lm/W
55 < W ≤ 75	90	.88	.72	57 lm/W
75 < W ≤ 105	90	.90	.72	58 lm/W
105 < W ≤ 155	98	.90	.72	63 lm/W
155 < W ≤ 255	105	.90	.72	68 lm/W
255 < W ≤ 405	105	.90	.72	68 lm/W

A **parametrized efficiency index of the lighting device (*IPEA*)** is then defined as reference parameter calculated in the following way:

$$IPEA = \frac{\eta_a}{\eta_r}$$

[9] By artistic lighting device is meant a luminaire of notable daytime aesthetic quality and special design for the lighting environment considered; they are intended for limited installation in areas of particular architectural and urban value or in historical city centers.

The energy classes of road lighting (IRA – Indice di rendimento dell'Apparecchio [luminaire efficiency index]) are therefore defined on the basis of the reference parameter:

INTERVALS OF ENERGY CLASSIFICATION	
Lighting devices energy class	*IPEA*
A+	*IPEA* > 1:10
A	1.05 < *IPEA* ≤ 1.10
B	1.00 < *IPEA* ≤ 1.05
C	0.93 < *IPEA* ≤ 1.00
D	0.84 < *IPEA* ≤ 0.93
E	0.75 < *IPEA* ≤ 0.84
F	0.65 < *IPEA* ≤ 0.75
G	*IPEA* < 0.65

Further considerations

On the basis of the definition given, it can be seen that HERA Luce has chosen to reward lighting devices equipped with high performance sources (taking as reference the best lamps in circulation today as regards quality/price ratio, represented by high pressure sodium lamps for road applications and halide lamps for other applications), electronic ballasts (which guarantee the greatest efficiencies) and high-yield optical systems.

It should be noted that in itself this indicator simply analyses the quality of the components; to get an idea of the performance in the field, see the paragraph below, which takes into consideration the energy efficiency of an installation. Generally, immediate substitution of fixtures with ***IPEA* < 0.50** value should be considered since they are highly inefficient.

Finally the certificate is compliant with the indications of the Authority regarding Minimum Environmental Criteria relative to Public Lighting: for this reason the certificate is already in compliance with legislation in force and with that to be issued in the near future.

Application Example

The following report takes into consideration various examples of lighting devices, which exemplify the installations present today in our country; the data refer to existing luminaires and serve to illustrate the effective applicability and value of the criterion proposed.
This classification obviously does not represent the whole panorama of luminaires present in Italy, but is useful solely to give a general idea concerning the behavior of the classification indicated in relation to the different types of luminaires and auxiliaries.

a) Lighting for roads and large areas

Luminaire 1		
Type	Road lighting luminaire without optical systems and without cup	**Global Efficiency** 28.93 lm/W
Description	Lighting device in aluminum without optical systems and without cup, with mercury vapor lamp and electromagnetic ballast.	**Luminaire Efficiency Index** IPEA = 0.35 **G**
Source type	Mercury vapor lamp 125W	
Source Eff.	50 lm/W	
Power supply output	0.89	
DLOR	65%	

Luminaire 2		
Type	Medium quality road lighting luminaire with prismatic cup	**Global Efficiency** 53.68 lm/W
Description	Medium quality lighting device, with high pressure sodium lamp and electromagnetic ballast.	**Luminaire Efficiency Index** IPEA = 0.72 **F**
Source type	High pressure sodium lamp 100W	
Source Eff.	90 lm/W	
Power supply output	0.84	
DLOR	71%	

Luminaire 3		
Type	Medium quality road lighting luminaire with prismatic cup	**Global efficiency** 67.84 lm/W
Description	Medium quality lighting device, with super high pressure sodium lamp and electromagnetic ballast.	**Luminaire Efficiency Index** IPEA = 0.90 **D**
Source type	High pressure sodium lamp 100W	
Source Eff.	105 lm/W	
Power supply output.	0.91	
DLOR	71%	

Luminaire 4		
Type	Good quality road lighting luminaire with flat glass	**Global efficiency** 76.44 lm/W
Description	Good quality lighting device, with super high pressure sodium lamp and electronic ballast.	**Luminaire Efficiency Index** IPEA = 1.02 **B**
Source type	High pressure sodium lamp 100W	
Source Eff.	105 lm/W	
Power supply output	0.91	
DLOR	80%	

Luminaire 5		
Type	Excellent quality road lighting luminaire with flat glass	**Global efficiency** 85.50 lm/W
Description	Excellent quality lighting device, with high yield metal halide lamp and electronic ballast.	**Luminaire Efficiency Index** IPEA = 1.14 **A+**
Source type	High yield metal halide lamp 90W	
Source Eff.	116 lm/W	
Power supply output	0.91	
DLOR	81%	

Luminaire 6		
Type	Good quality road lighting luminaire with LED source	**Global Efficiency** 71.00 lm/W
Description	Good quality lighting device, with LED source and micro-reflectors.	**Luminaire Efficiency Index** IPEA = 0.95 **C**
Source type	72 LED 6000K i=350mA	
Module power	82 W	
App. efficiency	71 lm/W	
Dff	100%	

b) Lighting for pedestrian and cycling areas

Luminaire 7		
Type	Good quality luminaire for pedestrian and cycling areas with flat glass	**Global efficiency** 57.10 lm/W
Description	Good quality lighting device, with metal halide lamp and electronic ballast.	**Luminaire Efficiency Index** IPEA = 1.02 **B**
Source type	Metal halide lamp 70W	
Source Eff.	88 lm/W	
Power supply output.	0.91	
DLOR	71%	

Luminaire 8		
Type	Excellent quality luminaire for pedestrian and cycling areas with LED source	**Global efficiency** 63.20 lm/W
Description	Excellent quality lighting device, with LED source and micro-optical systems.	**Luminaire Efficiency Index** IPEA = 1.26 **A+**
Source type	40 LED 6000K i=350mA	
Module flux	4000 lm	
Real Power	50 W	
Dff	79%	

4.2 Energy efficiency index of Public Lighting installations

The Kyoto convention marked the beginning of the search for ways of limiting global warming; this scenario laid the foundations for the energy consumption limits requisites received from the European Community by means of the EuP (*Energy Using Product*) directives.

The introduction of energy efficiency criteria (like that indicated by **prEN 13201-5**) makes choosing and developing products and services connected with public lighting easier among the European Community members: a well designed lighting installation reduces consumption, increases the average life cycle of the components and reduces maintenance intervention.

To achieve the objectives of savings in TOE (or CO_2 emissions) it is therefore necessary to define the efficiency of a public lighting installation on the basis of the energy used to satisfy the lighting engineering requisites established by the **UNI EN 13201-2** norm. The reference parameter chosen is the criterion of energy efficiency for road lighting defined by the **prEN 13201-5** called *SLEEC* (*Street Lighting Energy Efficiency Criterion*), divided into *SL* for lighting engineering design in luminance and *SE* for lighting engineering design in illuminance.

The comparison parameters are instead established on the basis of technical norms in force, EuP directives and others inherent to energy saving, the norms of other member states regarding public lighting energy efficiency and the performance requirements defined according to Best Available Technologies.

The same criterion has recently been adopted within the proposal for minimum environmental criteria for the purchase of HID lamps and LED systems, lighting sources, lighting installations within the National Plan of Action on Green Public Procurement (PANGPP) recently published on the Ministry of the Environment site.

This parameter seems more complete compared to the indication of energy consumption per kilometer because it also introduces an evaluation of the performances developed.

Definition

For stretches that are predominantly motorized, where the **UNI 11248** norm requires a calculation in luminance, the *SLEEC* for luminance is used; the *SL* value is defined as:

$$SL = \frac{P_{reale}}{L_m \cdot i_{rif} \cdot l_{media}} = \left[\frac{W}{cd/m^2 \cdot m^2} \right]$$

For mixed stretches, where the **UNI 11248** norm calls for a calculation in illuminance, the *SLEEC* for illuminance is used; the *SE* value is defined as:

$$SE = \frac{P_{reale}}{E_m \cdot i_{rif} \cdot l_{media}} = \left[\frac{W}{lux \cdot m^2} \right]$$

in which are defined:

P_{reale} : The real power absorbed by the luminaire, i.e. the sum of the powers absorbed by lamps and components inside the luminaire itself (starter, ballast/reactor, condenser, etc…) which can absorb electrical energy; this power is what the luminaire should theoretically absorb from the electrical lines during its normal operations. This power can be expressed as $P_{sorgente}/\eta_b$ in which $P_{sorgente}$ is the nominal power of the source and η_b is the ballast output.

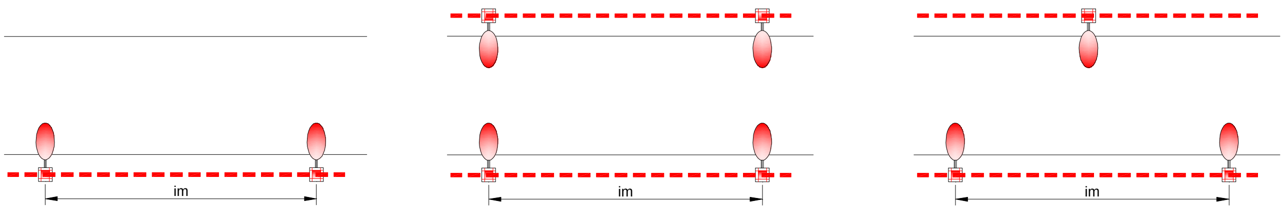
l_{media} : Average width of the carriageway or of the illuminated area.

L_m : Average maintained luminance calculated in accordance with the **UNI EN 13201** directives, adopting a maintenance factor of 0.80[10] and class C2 road surface.

E_m : Average maintained illuminance calculated in accordance with the **UNI EN 13201** directives, adopting a maintenance factor of 0.80.

i_{rif} : The reference interdistance in a public lighting installation between one light point and the other measured following the pattern shown below

Single line installation : $i_{rif} = i_m$ Dual line installation : $i_{rif} = i_m/2$ Staggered installation : $i_{rif} = i_m/2$



where i_m is the average interdistance between two successive light points situated on the same side of the carriageway.

In those cases where it is not possible to refer to a type of installation with homogeneous lines of lighting devices for the illuminance calculation, the *SE* value can be calculated in the following way:

$$SE = \frac{P_{reale}}{E_m \cdot s_{media}} = \left[\frac{W}{lux \cdot m^2} \right]$$

in which are defined:

P_{reale} : The real power absorbed by the luminaire, i.e. the sum of the powers absorbed by the lamps and by the components inside the luminaire itself (starter, ballast/reactor, condenser, etc…) which can absorb electrical energy; this power is what the luminaire should theoretically absorb from the electrical lines during its normal operations. This power can be expressed as $P_{sorgente}/\eta_b$ in which $P_{sorgente}$ is the nominal power of the source and η_b is the ballast output.

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[10] For calculations of energy coefficients shown below – unless otherwise indicated – the maintenance factor used is the conventional value MF = 0.80; should a different maintenance factor be desired in the future, the reference parameters will be scaled accordingly.

E_m : Average maintained illuminance calculated in accordance with the **UNI EN 13201** directives, adopting a maintenance factor of 0.80.

S_{media} : The average area illuminated by each lighting device; where a number of luminaires operate in the same area, the area will have to be divided by the number of luminaires in order to obtain the theoretical average area illuminated.

In all cases it is important to consider that the average maintained illuminance and luminance must always refer to the **lighting engineering design class** defined on the basis of the risks analysis carried out on the installation under examination and calculated using a maintenance factor of MF=0.80 and a class C2 road surface: the calculation in fact does not consider the contingent situation in which an installation may be found (relating therefore to external factors, such as frequency of maintenance or variations in traffic frequency at different times), but the absolute values to be compared.

This does not exclude taking into consideration, when possible, the reduction of powers by the system (due for example to the operation of point by point or cabin regulators) should the reduction in flux limit the possible surplus of luminance/illuminance that emerges from the lighting engineering calculation; reduced power can only be considered when the installation presents these values consistently from the initial startup[11].

Analyzing the formulae presented, it is possible to note that they contain in any case the consumption per meter, indicated as P_{reale}/I_{media} and therefore this confirms that the *SLEEC* represents a more accurate term of comparison, since it also introduces an evaluation of the illuminated area and of the quantity of light emitted.

On the basis of analyses carried out by HERA Luce on this parameter, a notable discrepancy emerges when, adopting the same characteristics of lighting devices and installation geometry, the interaxis between the light points is varied: in fact it appears that, by reducing the interaxis by several meters, a lower *SLEEC* is obtained (and therefore greater energy efficiency), while in reality the consumption per kilometer increases. For this reason, when defining the calculation parameters, a corrective factor k_{inst} has been inserted to make allowances for these discrepancies and to favor installations with greater interaxes.

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[11] For example, let us examine a hypothetical installation in class ME3c, with luminaires with SAP 150W lamps and an electronic dimmable ballast (with absorbed power at 100% of the flux equal to 165W) which presents average maintained luminance values of 1.15 cd/sq.m; in this case it is possible to reduce the luminous flux by 15% in a constant manner to comply with norm values and thus utilize around 135W of power instead of 165W (practically this means that, thanks to the possibilities offered by the system of flux reduction, it is “virtually” possible to use a sodium lamp of approximately 120W). The reduction in flux and in power can be used for all types of source and system that allow constant dimming, from the moment of switching on.
Excluded from this however remain all the temporary and non-guaranteed reductions for the entire life cycle of the installation (such as for example reductions after midnight due to diminished traffic flux or variation in service category).
Moreover, for all installations that do not allow regular definition of consumption (obtainable for example with a remote control dimmable electronic ballast), an average reduction in power must be defined; in the presence of a cabin reducer for example the loss of power at the beginning of the examined line must be evaluated to then reach an average with the values at the end of the installation (with a start at 200V and an arrival at 180V it would be necessary to consider 190V on average of reduction).

Energy classification

Once the SL value has been obtained (or resp. SE), the parameterized efficiency index of the installation ($IPEI$[12]) is calculated as the ratio between this parameter and the $SLEEC$ reference value SL_R (or resp. SE_R) for the lighting engineering class of the installation in question; this ratio is then multiplied by the coefficient k_{inst} which takes into account the fact that an installation is proportionately better the closer the design luminance (or resp. design illuminance) is to the reference parameter indicated in the **UNI 11248** norm: this allows the maximum inter-distance between the light points to be obtained thus ensuring a lower consumption of electrical energy per kilometer.

The formulae are thus as follows:

- roads ambit: $$IPEI = \frac{SL}{SL_R} \cdot k_{inst} = \frac{SL}{SL_R} \cdot \left(0{,}524 + \frac{L_m}{L_{m,rif} \cdot 2{,}1}\right)$$ in cui $k_{inst} = 1$ se $L_m < L_{m,rif}$

- other ambits: $$IPEI = \frac{SE}{SE_R} \cdot k_{inst} = \frac{SE}{SE_R} \cdot \left(0{,}524 + \frac{E_m}{E_{m,rif} \cdot 2{,}1}\right)$$ in cui $k_{inst} = 1$ se $E_m < E_{m,rif}$

in which are defined:

SL (SE) : The $SLEEC$ for luminance or illuminance as they emerge from lighting engineering calculations.

SL_R (SE_R) : The reference $SLEEC$ for luminance or illuminance as indicated in the following tables.

k_{inst} : Corrective factor which rewards compliance with the luminance or illuminance factors defined by the **UNI EN 13201** norm: thanks to this factor, those luminaires that with similar characteristics can guarantee a greater interdistance, obtain rewarding values.

L_m : Average maintained luminance resulting from the lighting engineering calculation carried out in accordance with the **UNI EN 13201** directives, adopting a maintenance factor of 0.80[13] and a class C2 road surface.

E_m : Average maintained illuminance resulting from lighting engineering calculation carried out in accordance with the **UNI EN 13201** directives, adopting a maintenance factor of 0.80.

$L_{m,rif}$: Reference average maintained luminance, referred to the lighting engineering class of the project undertaken.

$E_{m,rif}$: Reference average maintained illuminance, referred to the lighting engineering class of the project undertaken.

The reference values for classes ME and MEW (SL_R), as well as for class S (SE_R), have been inferred from the average of several calculation simulations in different lighting device ambits compliant with the indications of **n.**

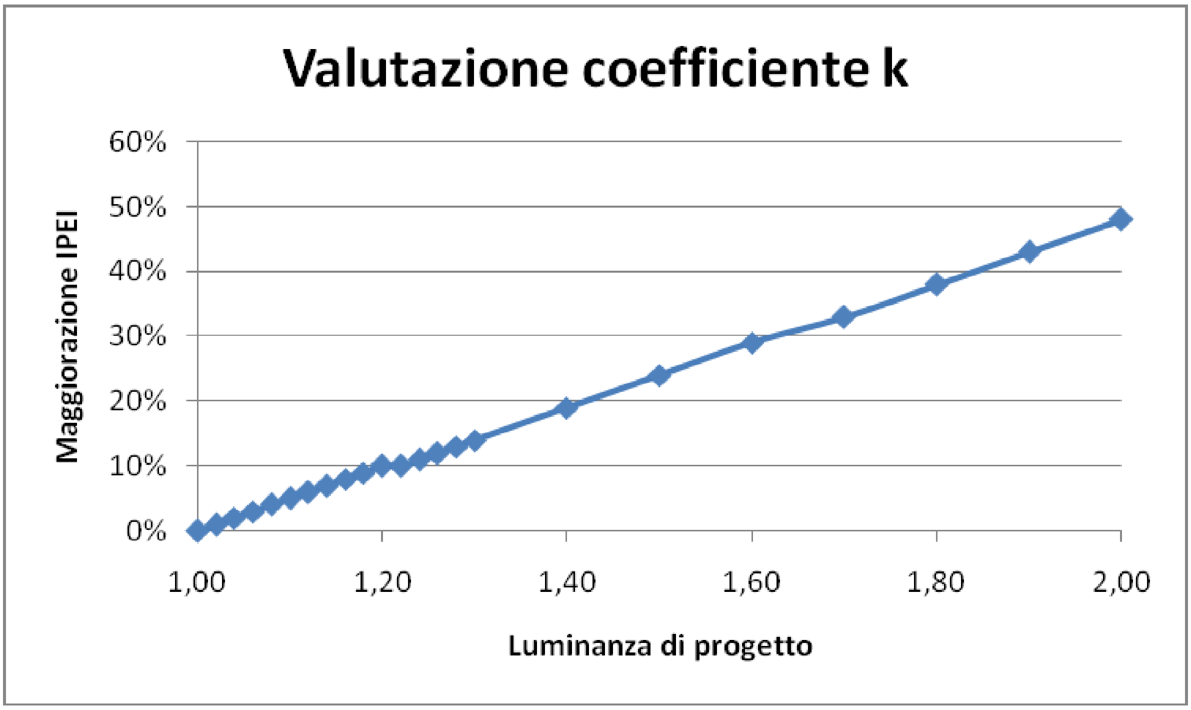
[12] Cf. what has already been published in Europe in the Spanish R. D. 1890/2008.

[13] For the calculations of the energy coefficients here below – unless otherwise indicated – the maintenance factor used is the conventional value MF = 0.80; should a different maintenance factor be desired in the future, the reference parameters will be scaled accordingly..

245/2009 regulation of the European Commission, representing middle range products with respect to the *BAT* available today; the corresponding reference value for classes CE (SE_R) has been inferred – as happens for **UNI 11248** – by multiplying the road reference values by the average reflection factor of the road surface; to standardize the results obtained, a standard road surface defined as road surfacing of Class C2 normalized in dry conditions having average luminance factor Q_0=0.07, is taken into consideration for the lighting engineering calculations.

The k_{inst} parameter guarantees the alignment of the results with the best performances, because it "scales" the illuminance (or luminance) surplus supplied by an installation in such a way that beyond a certain limit there are no advantages in giving more light than necessary.

The graph below can give an idea of how this works on a hypothetical coefficient: in this case an ME3c lighting engineering project has been examined (with average maintained luminance of 1.00 cd/sq.m).



As the graph shows, the more the project luminance differs from that indicated by the UNI 13201-2 norm, the more the efficiency index is penalized. If we look at the extended formula, we see this is due to the fact that the project luminance is penalized by the same percentage as indicated by the graph: for example for a project luminance of 1.40 cd/sq.m, a penalization of 19% is presumed and therefore the calculation is carried out as if the project luminance were 1.18 cd/sq.m.

This coefficient does not completely nullify the benefits of the extra luminance supplied: it simply limits itself to cutting part of the surplus during calculations (since it is logical that the closer an installation complies with the norm values, the better it will be).

At this point it is easy to demonstrate that, thanks to the introduction of this parameter, all the values align in such a way that the best installations are those that guarantee – with surrounding conditions equal – the greater interdistances between the light points[14].

The following tables show:

- the reference SLEEC values in relation to the illumination classes foreseen by the designer in accordance with the **UNI 11248** and **UNI EN 13201** norms for the installation; in the case of existent installations the illumination class however refers to the geometric features of the road and traffic characteristics
- the energy classification corresponding to the different *IPEI* intervals

a) Road lighting

***SL_R* REFERENCE TABLE**	
Road lighting Classes ME and MEW	
Lighting engineering class	**Reference SLEEC of *SL_R* (W/cdm^{-2}/m^2)**
ME1 / MEW1	0.49
ME2 / MEW2	0.51
ME3a	0.56
ME3b / MEW3	0.55
ME3c	0.54
ME4a / MEW4	0.58
ME4b	0.57
ME5 / MEW5	0.60
ME6	0.65

b) Historical city centers and intersections lighting

***SE_R* REFERENCE TABLE**	
Intersections and historical centers lighting Classes CE	
Lighting engineering Class	**Reference SLEEC of *SE_R* (W/lx/m^2)**
CE0	0.033
CE1	0.035
CE2	0.037
CE3	0.039
CE4	0.042
CE5	0.044

[14]Let us propose, for example, two solutions for a certain installation, with road width of 8m and class CE3: the first, with halide centers of 175W total, situated at 30 m interdistance, Em = 22lx, with efficiency parameter SE = 175/22x8x30 = 0.0331W/lx m2; the second, with centers of 120W total, situated at 28 m interdistance, Em = 15lx, with efficiency parameter SE = 120/15x8x28 = 0.0357W/lx m2.
In this way, in the first case we will have IPEI=1.04 while in the second IPEI=0.92 which is substantially more efficient than the first.
The waste is less than 36% (which is what we would have simply comparing the energy consumption per kilometer) because it tells us that, effectively, lighting with an average of 22 lux on the ground is not too bad, because it could by rights fall into the superior lighting engineering category (CE2); yet it is less efficient because in this case the designer has made a mistake in the choice of lighting engineering solution.

c) Sidewalks, pedestrian and cycling areas, car parks lighting

SE_R REFERENCE TABLE	
Lighting for sidewalks, pedestrian and cycling areas, car parks Classes S	
Lighting engineering class	**Reference SLEEC of SE_R ($W/lx/m^2$)**
S1	0.07
S2	0.08
S3	0.09
S4	0.11
S5	0.14
S6	0.17
S7	0.21

A **parametrized efficiency index of the lighting installation** will thus be defined on the basis of the reference parameter

ENERGY CLASS GRADING	
Installation energy class	***IPEI***
A+	*IPEI* < 0.82
A	0.82 ≤ *IPEI* < 0.91
B	0.91 ≤ *IPEI* < 1.09
C	1.09 ≤ *IPEI* < 1.35
D	1.35 ≤ *IPEI* < 1.79
E	1.79 ≤ *IPEI* < 2.63
F	2.63 ≤ *IPEI* < 3.10
G	*IPEI* ≥ 3.10

Further considerations

The criterion now expressed, as indicated in the notes, already appears in numerous laws and bills throughout Europe (please refer to the example Spanish **Real Decreto 1890/2008**).

Moreover it is in line with Authority legislation concerning the Minimum Environmental Criteria as regards public lighting: for this reason the certificate already complies with legislation in force and with that forecast for the near future.

Also in this case, preference has been given to those installations equipped with electronic power supply, high performance sources and optical systems that can guarantee the largest interdistances possible in complete respect of the parameters defined by the **UNI EN 13201** norm.

Application example

In the following report, the different types of installations taken into consideration exemplify the installations present today in our country; also in this case the data refer to existing luminaires and serve to illustrate the effective applicability and value of the criterion proposed.

Case 1 : Local urban road – 6.0m of carriageway with two lanes in opposite directions – single line installation on roadside, height of installation at 7.0m and distance from roadside 0.0m. Excellent quality lighting device (class *IPEA* A), with electronic ballast and super high pressure sodium lamp 70W.

Class	Luminaire				Geom.		Calculation					Lum. eff..		Installation efficiency		
Class	Lum. eff. source (lum/W)	Abs.pow. (W)	Eff. power supply (%)	Dlor (%)	Int. (m)	i/h	Lm (cd/m^2)	U0	Ul	Ti (%)	SR	*IPEA*	Cl. *IPEA*	*SLEEC*	*IPEI*	Class *IPEI*
ME4b	94	77	91	81.2	33	4.7	0.75	0.4	0.5	15	0.5	1.07	A	0.52	0.91	A
ME4b	94	77	91	81.2	32	4.6	0.77	0.4	0.5	15	0.5	1.07	A	0.52	0.93	B
ME4b	94	77	91	81.2	31	4.4	0.79	0.4	0.5	15	0.5	1.07	A	0.52	0.94	B
ME4b	94	77	91	81.2	30	4.3	0.82	0.4	0.6	14	0.5	1.07	A	0.52	0.96	B
ME4a	94	77	91	81.2	32	4.6	0.77	0.4	0.6	15	0.5	1.07	A	0.52	0.91	A

From the table it can be seen that a good quality luminaire with efficient optical system (able therefore to obtain large interdistances, as shown in the ratio i/h=4.7) is ranked in class A (1^ line).

In support of what was said in the introduction, it can be seen that with a reduction of the interdistance, the luminance increases and the *SLEEC* instead is identical: this parameter therefore cannot alone detect the increase in savings that results from increased interdistances (1^-4^ line); on the contrary, the *IPEI* parameter that we introduced considers this behavior abnormal and shows a penalization for the choice of smaller interdistances (to the extent that, for smaller interdistances, the class passes from A to B).

Moreover it is possible to note that, when passing to a higher lighting engineering class (from ME4b to ME4a), the *IPEI* parameter remains unchanged (5^ line). This shows that, even with a smaller interdistance, the luminaire in question is used at the maximum of its possibilities for each lighting engineering class.

The parameter indicated gives a more detailed description with respect to the parameter relative to the lighting device: it can be observed in fact that while the *IRA* classification remains unchanged (insofar as the specifications of the luminaire are unvaried), the *IPEI* classification crucially depends on how this luminaire is used and above all on whether it is able to correctly and efficiently illuminate the area under examination.

Case 2 : Minor urban road – carriageway with two lanes in opposite directions – single line installation on roadside and distance from roadside 0.0m.
Excellent quality lighting device (class *IPEA* A), with electronic ballast and super high pressure sodium lamp 100W.

Class		Luminaire				Geom.			Calculation					Lum. eff.		Installation efficiency		
Class	Wid. (m)	Lum. eff. source (lum/W)	Abs. pow. (W)	Power supply eff. (%)	Dlor (%)	Int. (m)	h (m)	i/h	Lm (cd/m^2)	U0	Ul	Ti (%)	SR	*IPEA*	Cl. *IPEA*	*SLEEC*	*IPEI*	Class *IPEI*
ME3c	6.0	107	115	87	81	38	7.5	5.1	1.00	0.4	0.5	14	0.6	1.01	B	0.50	0.93	B
ME3c	6.0	107	110	91	81	38	7.5	5.1	1.00	0.4	0.5	14	0.6	1.05	A	0.48	0.89	A
ME3c	6.0	107	110	91	81	34	7.0	4.9	1.10	0.4	0.5	15	0.6	1.05	A	0.49	0.95	B
ME3c	6.0	107	110	91	81	32	7.0	4.6	1.20	0.4	0.6	15	0.5	1.05	A	0.48	0.97	B
ME3c	6.0	107	110	91	81	30	7.0	4.3	1.30	0.4	0.7	14	0.5	1.05	A	0.47	1.00	B
ME3c	7.0	107	110	91	81	34	7.5	4.5	1.00	0.4	0.6	13	0.5	1.05	A	0.46	0.86	A
ME3c	8.0	107	110	91	81	30	8.0	3.8	1.00	0.4	0.8	11	0.5	1.05	A	0.46	0.85	A
ME3b	6.0	107	110	91	81	37	8.0	4.6	1.00	0.4	0.6	12	0.6	1.05	A	0.50	0.90	A
ME3b	7.0	107	110	91	81	34	8.0	4.3	1.00	0.4	0.7	13	0.5	1.05	A	0.46	0.84	A

Also in this case it can be observed that a luminaire of good quality and efficient optical system (capable therefore of large interdistances, as shown by the ratio i/h=5.1) is ranked in class A (2^ line); moreover it is seen that the use of an electromagnetic ballast, other conditions being equal, determines a reduction in class, both in the luminaire and in the installation ambit (1^ and 2^ lines). These results confirm the correct application of the method and complete fulfillment of the premises we indicated.

As previously seen, a reduction in interdistance between light points determines an increase in luminance and even a better *SLEEC* for smaller distances: this aberration is corrected by the parameter we introduced, which presents a higher *IPEI* parameter for lesser interdistances (2^ - 5^ lines).

Instead it can be seen that the increase of the road width (in this case from 6.0m to 8.0) determines a reduction of the *IPEI* parameter, even in the presence of smaller interaxes; this is due to the fact that the illuminated area appears greater in any case and moreover it seemed opportune to reward in some way the ability of the luminaires to supply the correct illumination also in transversal direction (2^, 6^ and 7^ lines).

Also in this case, passing into a higher category (from ME3c to ME3b) does not determine a substantial increase in the reference parameter, even in the presence of smaller interaxes (2^ and 8^ lines, 6^ and 9^ lines).

5. Drawing up Energy Certification certificates

The definition of energy certification indices is certainly a useful instrument that can help an inexpert user in the delicate choice of the best solutions; this index is not however sufficient on its own to fully define the characteristics of a lighting device, let alone a lighting installation.

For this reason HERA Luce, in addition to the energy criteria presented in the previous paragraph, intends to propose certificates that thoroughly illustrate the main characteristics of a system.

The main intent is that of supplying a valid tool that offers a general, comprehensible part to all, and a more specific part, designed for technicians, which can be a support in the choices linked with purchasing new lighting devices and installing new installations. One of the challenges in the near future will in fact be the development of environmental procedures within Public Administration: using their purchasing power to choose goods and services that also respect the environment, they can greatly contribute towards achieving sustainable development.

The *Green Procurement* initiatives are one of the market responses to the sustainability challenge: in these cases preference is given to the goods that possess "environmental preferability", meaning that they have less impact compared to similar goods.

The **2004/17/EC and 2004/18/EC directives** on tenders explicitly allows the selection boards to choose among specifications based on technical norms or performance requirements.

HERA Luce offers Public Administrations two different certificates, one referred to lighting devices and one to lighting installations, which define an energy class of comparison according to the technical norms in force and to the performance requirements defined by the *Best Available Technologies* procedures.

I am fully aware that the system we have prepared represents real innovation in the lighting field and therefore the main objective for the time being is to focus on the most important data in order to build a common platform in time with which to compare.

Thanks to the certificates presented, it will be possible to base the choice of a lighting device or the realization of a new installation on transparent and reliable criteria guaranteed by products which have been certified by a company who has always been involved in Public Lighting.

5.1 Energy certification for lighting devices

The first certificate proposed concerns lighting devices: the purpose is to supply a complete picture of the luminaire, regarding both technical characteristics and performance.

All these certificates will go to form a freely consultable database which will be presented to Public Administration whenever it is necessary to describe the lighting devices available using unequivocal criteria that permit comparison. This will allow the certificates to be used as a parameter to refer to when choosing pending installations: thanks to an unequivocal parameter and standard certificate with which to compare the various products, it will be easier for the Administrations to make their choices. HERA Luce offers themselves as guarantor of the data presented, reserving the right to verify what is declared by carrying out measurements during spot checks on already installed luminaires; where discrepancies are found in what has expressly been declared, the product will be removed or excluded from other possible certifications.

The certificate is designed to represent a single type of product that contains certain fixed components: the same luminaire that mounts a different lamp or a different ballast should have different certificates (since the efficiency of a ballast or a source can significantly affect performance); if possible it is hoped that a sole position will be chosen for luminaires with lampholder slide.

In addition to the aims expressed in the previous paragraphs, there is an urgent need for “standard” certification of those characteristics that every manufacturer should declare at the moment of sale but which are instead often omitted.

Thanks to this classification, there will be a secure database, certified by the manufacturers themselves with regards to the specifications of a certain lighting device: it will therefore no longer be possible to “adjust” the data to one’s convenience nor to give incomplete data. This gives a guarantee to the manufacturers who have a certified line and work honestly and transparently and, at the same time, it will keep at bay those trying to sell products that are absolutely unsuitable with wholly invented technical specifications.

Although not created for this purpose, the proposed certificate could represent a valid starting point for developing a luminaire catalogue, with uniform data for all manufacturers: the best defense against those who wish to cheat is certainly, in our opinion, transparency.

ATTESTATO DI CERTIFICAZIONE ENERGETICA APPARECCHIO ILLUMINANTE

Attestato numero : 0000000a Rilasciato il : 01/01/2010 da HERA Luce s.r.l.

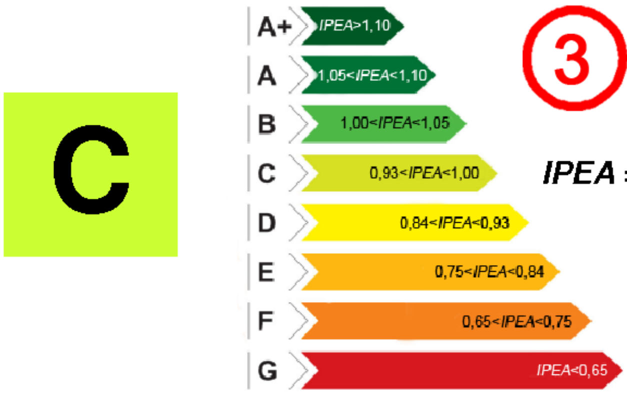
DATI APPARECCHIO

- **Produttore:** HERA Luce s.r.l.
- **Denominazione:** Apparecchio di prova
- **Sorgente luminosa:** Osram NAV-T super 4Y 70W
- **Ambito:** Illuminazione stradale

COMPILATORE

- **Nome:** Dott. Ing. Matteo Seraceni
- **Ditta:** HERA Luce s.r.l.
- **Data compilazione:** 01/01/2010
- **Rif. eulumdat:** xxx_xxx.ltd

CLASSE ENERGETICA (Indice Parametrizzato Efficienza Apparecchio)



IPEA = 0,98

INDICI PRESTAZIONALI

SORGENTI E N.RO	1 lampada SAP 70W	CARATT. SORGENTI	ST-70/20/4-H-E27-[illegible]156
TEMP. COLORE e Ra	Tc: 2700 K Ra: 24	TIPO OTTICA	Alluminio alta riflessione
CARATT. VANO	Pressofusione Ottica: IP64 Ausiliari: IP65	CLASSE ARMATURA	Classe II
ALIMENTATORE	Elettronico dimmerabile $Cos\varphi=0,95$ $\eta=0,91$	AFFIDABILITA' ALIM.	F.R. : 10% a 50.000 ore
FLUSSO SORGENTI (o flusso luminoso modulo)	6600 lm	POTENZA REALE	P_{reale} : 77 W
FLUSSO LUM. TOTALE (o efficienza luminosa apparecchio)	5350 lm	DURATA SORGENTI	14000h
LLMF	89%	LSF	90%
RISP. INQ. LUM.	L.R. 19/2003 E.R.	CERTIFICAZIONI	IMQ
COSTO INDICATIVO	250 euro	GARANZIA	3 anni dal produttore

Front page lighting device energy certificate – specifications:

1) **LUMINAIRE DATA**

Here the general luminaire data are shown; in the “Ambit” box the application area must be specified as defined in paragraph 4.1 (Road lighting, Pedestrian and cycling areas and car parks, etc.): no more than one ambit can be defined for the same luminaire.

2) **COMPILER**

In this part the compiler data, the company the compiler belongs to and date of compilation are defined; in the “Ref.” box is specified the reference file in eleumdat format which must compulsorily be attached to the certificate and will be filed with it.

3) **ENERGY CLASS**

On the basis of the application area chosen, the energy class will be calculated according to the definitions expressed in paragraph 4.1.

4) **PERFORMANCE INDICES**

In this section the main characteristics of the luminaire components are defined:

SOURCE AND NUM.	:	Indicate the code for lamp type and nominal power; for LED sources, indicate manufacturer, code, type and number of LEDs present in compliance with **CEI EN 62031:2008** and **UNI 11356:2010**.
SOURCE CHAR.	:	Indicate ILCOS classification; for LED sources indicate nominal power of the elementary source, power supply current and ambient temperature considered in accordance with **UNI 11356:2010**.
COLOR TEMP. and Ra	:	Indicate the color temperature expressed in Kelvin and the chromatic yield index as defined in **CIE 193** norm. The datum expressed must take into account any chromatic corrections obtained using screens, micro optical systems and other systems.
OPTICAL SYSTEM TYPE	:	Indicate the material used for the optical systems (i.e. high reflection aluminum); For LEDs indicate the optical system used to diffuse the light (i.e. micro optical systems, micro refractors, etc.).
BOX CHAR.	:	Indicate the material and degree of protection of the box according to the indications of **UNI EN 60529** norm.
FIXTURE CLASS	:	Indicate the luminaire insulation class.
BALLAST	:	Indicate the type, power factor, efficiency, if applicable, whether dimmable and remote controlled and compliant with the **CEI EN 61347** norm.
POWER SUPPLY RELIABILITY	:	Indicate the mortality rate relative to the period under examination on the basis of performed and certified trials[15].
SOURCE FLUX (or module luminous flux)	:	Indicate the initial nominal flux of the single source in normal conditions; for LEDs indicate also the luminous flux of the module according to the drive current indicated and at ambient temperature Ta=25°C.

[15] The trial methods and/or statistical extractions used to supply these date must be included.

REAL POWER : Indicate the total power absorbed by the lighting device[16]. By total power is meant the real power absorbed by the complete luminaire, as it is sold, during normal use and measured upstream of the luminaire itself, therefore including the luminous sources, ballast and any accessories. For LEDs also indicate the corresponding drive current.

TOTAL LUM. FLUX (or luminaire luminous efficacy) : For total luminous flux is meant the flux emitted by the luminaire (therefore deducting losses due to optical systems, etc…); if you wish to indicate the luminous efficacy of the luminaire, indicate the percentage of luminous flux leaving the luminaire in relation to the nominal luminous flux of the installed sources (LOR). For LEDs indicate the luminous efficacy of the luminaire in accordance with the **UNI 11356:2010** norm.

SOURCE LIFE CYCLE : Indicate the life cycle of the lamp with reference to a mortality of 10%.
In the case of LEDs indicate the lifecycle with reference to the flux reduction referred to L70; should you wish to indicate a different flux reduction, use whole numbers in tens (i.e. L80) and explain the corresponding life cycle[11].

LLMF : Indicate the luminous flux reduction of the sources with reference to the life cycle indicated, in accordance with the indications of the **CIE 154:2003** norm.
In the case of LEDs reference must be made to the life cycle explained in the SOURCE LIFE CYCLE parameter (i.e. to L80 corresponds a LLMF=0.80) and indicate the joint temperature considered.

LSF : Percentage of mortality of the lamps in reference to the life cycle indicated according to **CIE 154:2003** norm.
For LEDs indicate the percentage of sources that do not reach the lumen expected at end-of-life or that prove to be off, indicated with the letter B followed by the whole corresponding percentage (i.e. B50).

LIGHT POLLUT. RESP. : Indicate the light pollution response of the luminaire (e.g. Full Cut-Off or less in accordance with **CIE 1977** norm, or, if so regulated, with Lombardy regional norm, etc., or, if so regulated, with the norm on light pollution **UNI 10819**).

CERTIFICATIONS : Indicate the technical documentation that allows evaluation of the conformity of the electrical material with the requirements of the European directives applicable to obtain the CE mark; in particular:

- photometric reports in conformity with the **UNI EN 13032** norm plus any applicable second parts; released by an external or internal laboratory under supervision by third party in turn recognized SINCERT, SINAL or equivalent;
- conformity reports with Norms **CEI EN 60598-1**, **CEI EN 60598-2-3**, **EN 61000-3-2**, **EN 61000-3-3**, **EN 55015** and **EN 61547** released by an external or internal laboratory under supervision by third party in turn recognized SINCERT, SINAL or equivalent.

In the case of LEDs also indicate conformity with photo-biological safety indicated by the **EN 62471** norm.

LIST PRICE : Indicate the list price of the luminaire (gross price, without discounts) which will be subdivided in price ranges at intervals of 25 euro (i.e. 250 euro if the price falls between 238 and 263 euro; 275 euro if it falls between 263 and 288 euro).

GUARANTEE : Indicate the guarantee supplied by the manufacturer for the whole luminaire (including internal components; if the guarantee on one component is less than that on the other pieces, only the shorter term guarantee will be taken

[16] The technical data sheets of the product in which these characteristics are certified or the trial methods and/or statistical extractions used to supply these date must be included. For LED sources refer to the **UNI 11356:2010** norm.

into consideration); if the guarantee is extended, indicate length and cost.

5) DATA ARCHIVE

HERA Luce proposes the creation of a global archive of the certified lighting devices so as to make them available to the Public Administrations that request them; moreover this allows the certification of the data, their authentication and finally the absolute non-involvement in their eventual processing of HERA Luce, who act solely as guarantor of the data supplied.

GRUPPO HERA Hera Luce

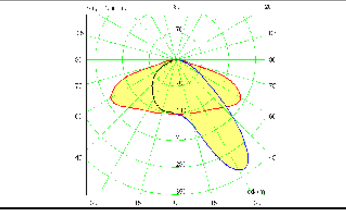
ATTESTATO DI CERTIFICAZIONE ENERGETICA APPARECCHIO ILLUMINANTE

Attestato numero : 00000000a Rilasciato il : 01/01/2010 da HERA Luce s.r.l.

CARATTERISTICHE FOTOMETRICHE

Rendimento	81%	Simmetria	90-270
DLOR	81%	Spread	60°
ULOR	0%	Throw	55°
Intensità massima	430 cd/klm	SLI	4,5
Posizione massimo	C=25° G=55°	Util. strada/marc.	0,53/0,26

Fotometria



DATI TIPICI DI INSTALLAZIONE

Ambito	Tipologia inst.	Altezza	Interdist.	Dist.	L_m	kWh/anno/km
ME4a – 6m carreggiata	Unifilare	7,2 m	28,0 m	0,0 m	0,76	**11077**
…						
…						

VALORI INDICATIVI DI MANTENIMENTO (LMF)

Livello di inquinamento	Periodo di esposizione, espresso in anni						
	1,0	**1,5**	**2,0**	**2,5**	**3,0**	**3,5**	**4,0**
Elevato	0,91	0,90	0,88	0,85	0,83	…	…
Medio	0,92	0,91	0,89	0,88	0,87	…	…
Basso	0,93	0,92	0,91	0,90	0,90	…	…

Data e firma

ALLEGATI:

Per la compilazione della presente certificazione si faccia riferimento al documento fornito da HERA Luce "Proposta per un modello condiviso di Certificati Energetici per apparecchi illuminanti e impianti di Pubblica Illuminazione".

Back page lighting device energy certificate – specifications:

1) **PHOTOMETRIC CHARACTERISTICS**[17]

In this part the photometric characteristics of the luminaire are indicated, in accordance with **CIE 1976** and **CIE 34-1977**:

Output (or LOR)	:	Ratio between luminous flux emitted by the luminaire and nominal luminous flux from the source inside.
DLOR	:	Ratio between luminous flux emitted by the luminaire directed towards the downward hemisphere and nominal luminous flux of the source inside.
ULOR	:	Ratio between luminous flux emitted by the luminaire directed towards the upward hemisphere and nominal luminous flux of the source inside.
Maximum intensity	:	Maximum luminous intensity of the measured photometry.
Maximum position	:	Position (expressed according to the angles of the two different photometric planes C and G) of the maximum point of luminous intensity.
Symmetry	:	Symmetry axis or plane present in the photometric curve.
Spread	:	Value of the angle to which 90% of the maximum value of luminous intensity on the C0-C180 plane corresponds.
Throw	:	Value of the angle to which 90% of the maximum value of luminous intensity on the C90-C270 plane corresponds.
SLI	:	Glare control index.
Road/sidewalk Util. factor	:	Percentage of luminous flux emitted that covers the defined area on sidewalk side and roadside.

2) **PHOTOMETRY**

The luminaire photometry is inserted in this box, indicating the following planes:

- C0 – C180 plane
- C90 – C 270 plane
- Maximum C plane according to indication in parameter “Maximum position”

3) **TYPICAL INSTALLATION DATA**

In this part the data relative to a “typical” installation must be supplied, of which all lighting engineering requisites are satisfied, by choosing already defined types, such as those indicated below as examples:

Road lighting luminaires

- Two lane road, one for each traffic direction, 6m carriageway, lighting engineering class of project ME4b, road surface class C2, single line installation with distance from verge 0m.
- Two lane road, one for each traffic direction, 6m carriageway, lighting engineering class of project ME3c, road surface class C2, single line installation with distance from verge 0m.
- Road with two lanes for each traffic direction with two traffic directions, 6.5m carriageway for each traffic direction, central reservation of 1m, lighting engineering class of project ME2, road surface class C2, double line installation sidewalk side with distance from verge 1.00m.

[17] The luminaire classification certificate is relative to only one type of lighting device; for discharge luminaires, when it is possible to have more than one position on the slide, it is advisable to only present the certificates relative to the most used slide positions.

Luminaires for lighting of pedestrian and cycling areas

- Pedestrian and cycling area 2m wide, lighting engineering class of project S3, road surface class C2, single line installation with distance from verge of 0m.
- Pedestrian and cycling area 1.5m wide, lighting engineering class of project S5, road surface class C2, single line installation with distance from verge 0m.

In the lighting engineering calculation presented as maintenance factor, a value of UF = LLMF x LMF x (LSF) is used; in which LLMF is that indicated in the table, LMF is that relative to 3 years exposure with low pollution level and LSF is that indicated in the table and must be calculated when it is not possible to substitute the individual light sources inside the luminaire; for LED sources it is presumed that the LSF parameter is integrated in the LLMF calculation (should this not be so, this parameter will also need to be taken into consideration).

4) INDICATIVE MAINTENANCE VALUES

In this part should be indicated the indicative maintenance values in accordance with the EC 129/2009 norm that expresses the LMF value in relation to environmental exposure (medium, low or high pollution) and the period of exposure considered between one cleaning and the other.

5) ATTACHMENTS

Here the attachments to the declaration are indicated, which complete and certify what has been declared, such as certificates or tests carried out on the luminaire.

6) DATA ARCHIVE

Please refer to section 5 of the previous page

5.2 Energy certification for an installation of Public Lighting

The second certificate concerns Public Lighting installations: in this case, the certificate will be attached to the project for a new installation and is designed as an evaluation of the consumption and installation maintenance methods: for this reason, rather than concentrating on the geometry of the installation (for which the project designs should be sufficient) it would seem more opportune to outline the indicators that represent the performance and energy consumption of the installation.

One of the problems that has emerged is that of defining an ambit on which to verify the energy class: if in some cases this is easily defined (for example a straight road that maintains the same geometry for its whole length), in others it appears hard to define a single field (for example a project for a road that in some stretches runs alongside the sidewalk and then opens into a square or traffic circle).

For this reason the certificate is designed to be subdivided into “main ambits”, which define the zone-type or the stretch-type taken into consideration in the lighting engineering calculation, which must be closely adhered to: “main ambit” therefore means an ambit or stretch-type that represents more than 90% of the area under examination; should there be two or more ambits covering predominant areas (for example 40% and 50%), it is necessary to refer to each main sub-ambit.

While the previous certificate examined the lighting device solely from the point of view of potential performance, this certificate evaluates its effective performance in the field; moreover a whole series of data is supplied, characterizing the installation throughout its operation cycle (from the materials used to the ordinary maintenance cycles and consumption of electrical energy). The objective is to supply a first indication on the *Life Cycle Assessment* of the technologies put into play, so as to identify the effective value of the installation from the date of installation to that of its disposal[18].

Note that the *IPEI* index refers to an absolute efficiency of the installation (and is therefore independent of the particular conditions in which it is found), while all the other values (maintenance factor, lighting engineering results, average consumption) refer to the real situation in which the installation is found.[19]

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[18] Although this is not the place for broad discussion on the evaluation policies for the life cycle of lighting products, it is important to highlight that the ordinary running costs of an installation represent almost 90% of the resources used in a complete *LCA* analysis: the definition of the parameters we have singled out thus leads to an incomplete but certainly thorough definition of the examined products.

[19] For example, when an installation is designed with a maintenance factor of 0.75 and flux reduction after midnight, in the *IPEI* calculation you must anyway consider a maintenance factor of 0.80 and installation power at 100%; in the quality parameters instead you will need to specify 0.75 as the maintenance factor and the effective consumption, thanks to the flux reduction applied, as the average yearly consumption.

ATTESTATO DI CERTIFICAZIONE ENERGETICA
IMPIANTO DI PUBBLICA ILLUMINAZIONE

Attestato numero : 0000000i   Rilasciato il : 01/01/2010

DATI INSTALLAZIONE

⇨ **Comune:** San Mauro Pascoli (FC)

⇨ **Ubicazione:** Via Bellaria Nuova

⇨ **Apparecchio:** HERA apparecchio di prova

⇨ **Ambito principale:** Strada urbana – Cat. ME4b

COMPILATORE

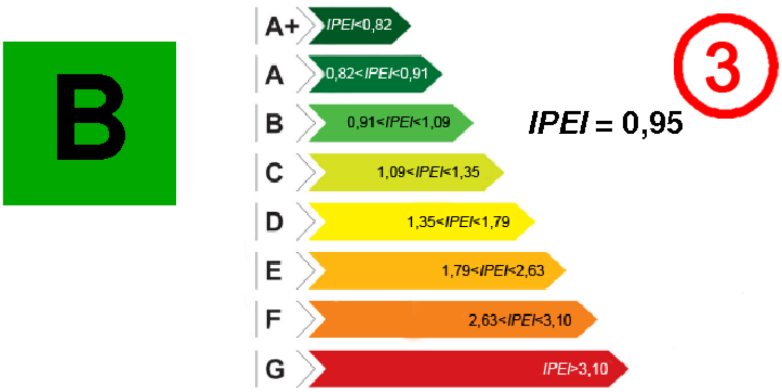
⇨ **Nome:** Dott. Ing. Matteo Seraceni

⇨ **Ditta:** HERA Luce s.r.l.

⇨ **Data installazione:** 01/01/2010

⇨ **Rif. prot.:** prot. XXXX del 01/01/2010

CLASSE ENERGETICA (Indice Parametrizzato Efficienza Impianto)



INDICI PRESTAZIONALI

AMBITO PRINCIPALE	Strada urbana – Cat. ME4b Carreggiata 6m (2x3m corsie) Coefficiente riflessione C2 (Q0=7,01)	
DATI DI INSTALLAZIONE	Tipologia di installazione : Altezza installazione : Interdistanza : Distanza ciglio Sbraccio : Rapporto I/A :	unilineare lato strada 7,2 m f.t. 28,0 m 0,0 m 0,0 m 3,89
ENTITA' IMPIANTO	Numero pali : Numero apparecchi : m coperti :	10 10 280 m
PARAMETRI DI QUALITA'	L_m: U0 : Ul : Ti : S.R. : Coefficiente di manutenzione : SL : Consumo medio : Parametro inquinanti :	0,75 cd/mq 0,4 0,5 6,76 % 0,5 0,80 0,54 W/mq/(cd/mq) 9000 kWh/anno/km 12 TEP/anno

Front page Public Lighting installation energy certificate – specifications:

1) INSTALLATION DATA

This part indicates the general data of the installation; in the "Main ambit" box, the ambit of application and project lighting engineering category as defined by the **UNI 11248** norm must be specified. "Main ambit" means that part of the project that covers more than 90% of the area of intervention; should there be ambits of more or less the same size which are predominant areas (for example one of 40% and another of 50%), it is necessary to complete two certificates, one for each ambit.

2) COMPILER

In this part the compiler data, the company the compiler belongs to and date of compilation are defined; in the "Prot. Ref." box is specified the reference protocol relating to the certificate of the lighting device used in the proposed ambit.

3) ENERGY CLASS

On the basis of the application ambit chosen, the energy class is calculated according to the definitions expressed in paragraph 4.2.

Should the maintenance factor or the road surface class used for calculating the installation to be set up be different from those of reference used in the calculation of the IPEI index, a new lighting engineering calculation must be carried out which, keeping the same geometric characteristics, uses an MF = 0.80 and a surface of C2. The calculation dedicated to the IPEI must therefore be carried out from scratch on the basis of the indicated factors, in accordance with lighting engineering norms.

4) PERFORMANCE INDICES

In this part the main characteristics of the luminaire components are defined:

MAIN AMBIT : In this case, the main application ambit is shown according to the above indications, as well as the project lighting engineering class as defined by the **UNI 11248** norm.
In the case of roads, indication must be made of the width of the carriageway under examination, the number of lanes and traffic directions, the width of each lane, and the average reflection factor. If the calculation also includes the sidewalk or a different area at the roadside which is calculated independently (therefore without using the S.R. indication), the geometrical characteristics of this area as indicated in this paragraph must be defined and if applicable the average reflection factor (when a luminance calculation is carried out on it).
With mixed traffic roads, the same indications are valid as for normal roads, except as regards the average reflection factor, which is only indicated if a luminance calculation is carried out.
In the case of cycling paths or sidewalks, indicate the width and if applicable whether the stretch is a pedestrian and cycling area.
For large areas or car parks, only indicate the size of the area illuminated by a single row of luminaires and the total width of the area.
In the case of a traffic circle, indicate the diameter of the island and of the coplanar belt, the internal diameter of the traffic ring road, the external diameter of the traffic ring road, the width of the carriageway, the number of

lanes, the width of each lane.

INSTALLATION DATA : In this field the data related to the position of the light points are entered.
In the case of roads, the installation type (single line roadside, single line road center, two facing lines, two staggered lines, two lines road center), installation height (i.e. the height reached by the luminaire support and calculated in meters from the ground), average interdistance between the light points, distance of the light point from the road verge (i.e. the distance of the luminaire baricenter with respect to the lateral limit on which they are installed, a positive distance indicates they are closer to the carriageway, a negative distance further away), length of the eventual bracket arm, ratio interdistance/installation height must be defined.
In the case of mixed traffic roads the same indications as above apply.
For cycling paths or sidewalks, the installation height, average interdistance between the light points, distance of the light point from the verge of the lane on which it falls, length of the eventual bracket arm, and ratio interdistance/installation height must be defined.
In the case of large areas or car parks, where possible the average area (expressed in square meters) covered by each light point must be indicated.
In the case of traffic circles the installation type (outer limit, inner limit, central), installation height, average distance between light points (not measured in a straight line, but following the curve of the traffic circle), distance of the light point from the road verge, length of the eventual bracket arm, ratio interdistance/installation height must be indicated.

INSTALLATION SIZE : Here the number of posts, luminaires and the total length of the installation are indicated.

QUALITY PARAMETERS : In this field the results of the lighting engineering calculation are inserted, carried out on the basis of the minimum requisites to be satisfied in compliance with **UNI 11248** norm.
Further to these data, there must also be indication of the maintenance factor used in the calculations, carried out in accordance with the indications of the **CIE 154:2003** norm and also shown on the back page of the certificate.
Also the reference SLEEC must be indicated, calculated in luminance or illuminance according to the visual task to be satisfied (please refer to the indications expressed in paragraph 4.2).
The average annual consumption per kilometer is calculated, according to the following calculation:

$$C_m = \frac{W_{medi}}{i_{rif}} \cdot h_{anno} = \frac{W_{totali}}{i_{rif}} \cdot h_{anno} \cdot k = \left[\frac{kWh/anno}{km} \right]$$

in which definition is made of:

W_{totali} : the total power absorbed by the luminaire, expressed in Watts;

i_{rif} : the reference interdistance, calculated according to the indications in paragraph 4.2, expressed in meters;

h_{anno} : the total annual operation hours of the installation (the standard is considered to be 4200 hours of annual operation; should these be different you must indicate the hours of operation adopted);

k : the reduction parameter due to any flux reduction programs adopted in accordance with indications on the back of the certificate sheet.

For calculating the CO^2 emissions in the atmosphere refer to the Ministry of the Environment data relative to the **1999 ENEL parameters** that set 580 kg of CO2 per 1 MW of energy.
Finally, calculation must be made of the TEP/year/kilometer by multiplying the average annual consumption per kilometer for the equivalent TEP/kWh (for conversion from kWh to tep it is necessary to take into account the

indications supplied by the **D.M. 20 July 2004** containing "New definition of the national quantity objectives of energy saving and development of renewable sources, in art. 16, comma 4, of the law decree 23 May 2000, n. 164", as modified by **EEN Resolution 3/08** "Updating of the factor of conversion of kWh in tonne equivalent of petroleum linked to the mechanism of the white certificates of energy efficiency", which indicates a conversion factor of **$0.187x10^{-3}$ tep/kWh**).

5) DATA ARCHIVE

HERA Luce proposes the creation of a global archive of the certified lighting devices certificates so as to make them available to the Public Administrations that request them; moreover this allows the certification of the data, their authentication and finally the absolute non-involvement in their eventual processing of HERA Luce, who act solely as guarantor of the data supplied.

GRUPPO HERA
Hera Luce

ATTESTATO DI CERTIFICAZIONE ENERGETICA
IMPIANTO DI PUBBLICA ILLUMINAZIONE

Attestato numero : 0000000i Rilasciato il : 01/01/2010

APPARECCHI ILLUMINANTI

APPARECCHIO 1: HERA Luce s.r.l. – Apparecchio di prova (rif. att. app. ill. 0000000a)			
SORGENTI E N.RO	1 lampada ST-70/20/4-H-E27-38/156	TEMP COLORE e Ra	Tc: 2700 K Ra: 24
CARATT. VANO	Pressofusione Ottica: IP64 Ausiliari: IP65	ALIMENTATORE	Elettronico dimmerabile $Cos\varphi=0,95$ $\eta=0,91$
CLASSE ARMATURA	Classe II	POTENZA ASS. SORGENTI E TOTALE	P_s : 70 W P_{tot} : 77 W
FLUSSO SORGENTI	6600 lm	FLUSSO LUM. TOTALE (o eventualmente efficienza luminosa apparecchio)	5350 lm
DURATA SORGENTI	14000h	RISP. INQ. LUM.	L.R. 19/2003 E.R.
PARAMETRI MANUTENTIVI	Cambio prog. ogni 3 anni comprensivo pulizia LSF = 100% LLMF = 89% LMF = 90%	PROGRAMMI RIDUZIONE FLUSSO	Dimm. variabile annuale K = 0,63
IPEA	0,98 (Classe C)	GARANZIA	3 anni dal produttore

N.B. Per eventuali altri apparecchi compilare le schede allegate

SOSTEGNI

SOSTEGNO 1: HERA Luce s.r.l. – Palo rastremato			
TIPOLOGIA	Palo rastremato trafilato a caldo	MATERIALE	Acciaio
CAR. GEOMETRICHE	L : 8000 mm H_{ft} : 7200 mm D_{base} : 127 mm D_{somm}: 79 mm Sp : 3,5 mm	VERNICIATURA	Vernice grigio ferro micaceo Codice colore: XXXX M523
SBRACCIO	n.n.	POZZETTO	n.n.

N.B. Per eventuali altri sostegni compilare le schede allegate

Data e firma

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ALLEGATI:

Per la compilazione della presente certificazione si faccia riferimento al documento fornito da HERA Luce "Proposta per un modello condiviso di Certificati Energetici per apparecchi illuminanti e impianti di Pubblica Illuminazione".

Back page Public Lighting installation energy certificate – specifications:

1) LIGHTING DEVICES

This part summarizes the main characteristics of the lighting devices, with direct reference to the registered luminaire certificate:

SOURCES AND NUM.	:	Indicate ILCOS classification and nominal power; for LED sources indicate manufacturing company, code, type and number of LEDs present and **CEI EN 62031:2008** conformity.
COLOR TEMP. and Ra	:	Indicate the color temperature expressed in Kelvin and the chromatic yield index as indicated in **CIE 193** norm.
BOX CHARACT.	:	Indicate the material and degree of protection of the box in accordance with the indications of the **UNI EN 60529** norm.
BALLAST	:	Indicate type, power factor, efficiency, if applicable if dimmable and operable with remote control and conformity with the **CEI EN 61347** norm.
FIXTURE CLASS	:	Indicate the insulation class of the luminaire.
ABS. AND TOTAL SOURCE POWER	:	Indicate the nominal power absorbed by the installed sources[20] and the total power absorbed by the luminaire; by total power is meant the real power absorbed by the luminaire during normal operation (therefore inclusive of lamps, ballast, losses, etc..) measured upstream of the luminaire itself.
SOURCE FLUX	:	Indicate the initial nominal flux of the individual source in normal conditions; for LEDs also indicate the corresponding drive current. In the case of LEDs it is obligatory to indicate the joint temperature with which the indicated factors are calculated.
TOTAL LUM. FLUX (or if applicable luminaire luminous efficacy)	:	By total luminous flux is meant the flux emitted by the luminaire (therefore deducting losses due to optical systems, etc…); for LEDs also indicate the corresponding drive current. If you wish to indicate the luminous efficacy of the luminaire, indicate the percentage of luminous flux leaving the luminaire in relation to the nominal luminous flux of the installed sources (LOR); for LEDs refer to the **CIE 127:2007** norm
SOURCE LIFE CYCLE	:	Indicate the lamp life cycle with reference to a mortality of 10%. In the case of LEDs indicate the life cycle with reference to the flux reduction referred to L70; if you wish to indicate a different flux reduction, use whole numbers in tens (i.e. L80) and explain the corresponding life cycle.
LIGHT POLL. RESP.	:	Indicate the light pollution response of the luminaire (e.g. Full Cut-Off or less in accordance with **CIE 1977** norm or, if so regulated, with Lombardy regional norm, etc. or, if so regulated, with the norm on light pollution **UNI 10819**).
MAINTENANCE PARAMETERS	:	In this box it must be indicated whether scheduled source replacement is planned and if so, with what frequency, the regularity of luminaire cleaning and in addition, on the basis of the indications of the lighting engineering project, the following parameters must be indicated: LSF – Lamp mortality percentage with reference to the life cycle indicated in accordance with the **CIE 154:2003** norm. In the case of LEDs indicate the percentage of sources that do not reach the expected lumen at end-of-life (i.e. at L70, 50% of the LEDs do not reach the expected lumens) indicated with the letter B followed by the whole of the corresponding percentage (i.e. B50). LMF – Luminous flux reduction percentage of the luminaire in accordance with **CIE 154:2003** norm and the indications in the luminaire certificate on the basis of the cleaning intervals and surrounding environmental

[20] The technical data sheets of the product in which these characteristics are certified or the trial methods and/or statistical extractions used to supply these date must be included.

conditions.
LLMF – Percentage of luminous flux reduction from the sources with reference to the indicated life cycle, in accordance with indications in **CIE 154:2003** norm.
In the case of LEDs refer to the life cycle explained in the SOURCE LIFE CYCLE parameter (i.e. to L80 corresponds an LLMF=0.80).

The maintenance factor used in the lighting engineering calculation derives from these parameters and is calculated as:

UF = LSF x LMF x LLMF

FLUX REDUCTION PROGRAMS : Indicate flux reduction programs if foreseen.
In this case also indicate the average dimming factor (K) calculated in the following way:

- Define an annual hourly table of the effective dimmed hours

Dimming (*D*)	% power used (r_p)	Hours (*h*)
100	100%	2200
50	55%	1000
25	35%	1000
	Total	4200

- The average dimming factor (K) is calculated on the total hours of operation

$$K = \frac{\sum (r_p \cdot h)}{h_{anno}}$$

This factor indicates the ratio between the real consumption of electrical energy of the system on the basis of the dimming program effected and the consumption of electrical energy of the same system but running at full power during all hours of lighting.

IPEA : Indicate the Luminaire Output Index as indicated in paragraph 3.1

GUARANTEE : Indicate the guarantee supplied by the manufacturer for the whole luminaire (therefore including the internal components; if the guarantee on one component is less than that on the other pieces, only the shorter term guarantee will be taken into consideration); if the guarantee is extended, indicate length and cost.

Should there be more than one lighting device it is possible to complete additional certificates specifically for them.

2) SUPPORTS

In this part the main characteristics of the light point supports are summarized:

TYPE : Indicate the construction type of the support (for example heat tapered, cold laminate, etc…).

MATERIAL : Indicate the support material.

GEOMETRICAL CHARACTERISTICS	**:**	Indicate the geometrical characteristics of the support installation. If a post, indicate the overall length, height above the ground, diameter at the base, diameter at the top, core thickness. In the case of bracket arm or shelf, indicate the height of positioning.
PAINTING	**:**	In the case of painted posts, indicate the material used for painting and the color code.
BRACKET ARM	**:**	If there is an bracket arm or a shelf, indicate the bracket arm length and its construction characteristics.
MANHOLE	**:**	Indicate, if any, the size and material of the manhole near the light points (in the case of different types or of their presence only for some light points, indicate the most common type).

3) ATTACHMENTS

In this part the attachments to the declaration that complete and certify what has been declared, such as certificates or tests carried out on the luminaire, are indicated. In addition any further attached certificates relating to supports and lights must be indicated.

4) DATA ARCHIVE

Please refer to section 5 of the previous page

Practical example of calculation for installation certification

In this paragraph the necessary steps for the correct completion of the certification sheet relating to public lighting installations are precisely described.

Let us take for example a type F2 local urban road, with two lane carriageway of total width 6.50m and overall length of 200m.

On the basis of the **UNI 11248** norm we have a **ME4b lighting engineering reference category**:

		50		
E	Strade urbane interquartiere	50	ME3c	
	Strade urbane di quartiere	50		
F	Strade locali extraurbane (tipi F1 e F2[4])	70 - 90	ME3a	6.3
	Strade locali extraurbane	50	ME4b	
		30	S3	
	Strade locali urbane (tipi F1 e F2[4])	50	ME4b	
	Strade locali urbane: centri storici, isole ambientali, zone 30	30	CE4	
	Strade locali urbane: altre situazioni	30	CE5/S3	
	Strade locali urbane: aree pedonali	5		
	Strade locali urbane: centri storici (utenti principali: pedoni, ammessi gli altri utenti)	5	CE5/S3	
	Strade locali interzonali	50		
		30		
	Piste ciclabili[5]	Non dichiarato	S3	
	Strade a destinazione particolare[5]	30		

It is decided to use a 50 LED at 6000K road lighting luminaire, fed at 525 mA (with total power absorbed 78W and total flux 9415lm), with index *IPEA=1.18* (class A+).

On the basis of the risk analysis, we have a **lighting engineering design category** of ME4b (-1) (+1) (+1) = **ME4a**:

Parametro di influenza		Variazione categoria illuminotecnica	Non si applica a
Compito visivo normale		-1	A_1
Condizioni non conflittuali			
Flusso di traffico <50% rispetto al massimo			
Flusso di traffico <25% rispetto al massimo		-2	
Segnaletica cospicua nelle zone conflittuali		-1	
Colore della luce	con indice di resa dei colori maggiore o uguale a 60 si può ridurre la categoria illuminotecnica	-1*)	
	con indice di resa dei colori minore di 30 si deve incrementare la categoria illuminotecnica	1	
Pericolo di aggressione			
Presenza di svincoli e/o intersezioni a raso		1	
Prossimità di passaggi pedonali			
Prossimità di dispositivi rallentatori			

*) In relazione a esigenze di visione periferica verificate nell'analisi dei rischi.

The maintenance plan chosen is to clean the glass approximately every 4 years (LMF = 0.89 in clean environment) and to replace the luminaire after 50,000 hours of operation (decay factor of the luminous flux at end-of-life L85). On the basis of the guarantees and data supplied by the diode manufacturer, a mortality of LED diodes LED of approximately 2% at 50.000 hours is forecast (LSF = 0.98).

On the basis of the indications of the **CIE 154.2003** norm, a maintenance factor for the calculation is defined as follows:

MF = LMF x LLMF x LSF = 0.89 x 0.85 x 0.98 = 0.74

On the basis of the lighting engineering calculation it is possible to realize the following installation:

Installation Type	MF	h p.l. (m)	I (m)	Carriageway	Bracket arm
unilateral	0.74	7	29	2 lanes 6.5m total	NO
Class ME4a (UNI 11248)					
Average Luminance	**Uniformity**		**Glare**	**S.R.**	
Lm [cd/m^2]	**U_0**	**U_l**	**TI**		
0.75	**≥ 0.40**	**≥ 0.60**	**≤ 15%**	**> 0.5**	
LIGHTING ENGINEERING RESULTS					
Lm [cd/m^2]	**U_0**	**U_l**	**Ti (%)**	**S.R.**	
0.75	0.52	0.63	12.07	0.87	

In addition two further **lighting engineering operation categories** are defined on the basis of the volume of the traffic present:

Timetable	Traffic Flux	Lighting engineering category variation	Lighting engineering operation category
Startup → 22:00	100%	+0	ME4a
22:00 → 24:00	50%	-1	ME4b
24:00 → 6:00	25%	-2	ME5
6:00 → Turnoff	100%	+0	ME4a

From 24:00 to 7:00 it is therefore possible to forecast a luminous flux reduction of approximately 33% of that at service startup and therefore the average dimming factor K is calculated in the following way:

Dimming (*D*)	% power used (r_p)	Hours (*h*)
100	100%	2000
66	70%	2200
	Total	4200

$$K = \frac{2000 \cdot 1.00 + 2200 \cdot 0.70}{4200} = 0,84$$

The total consumption is therefore 78*4200/1000*0.84*1000/200 = 1376 kWh/year/km (corresponding to 0.05 TEP/year and 148 $kgCO^2$/year).

To calculate the IPEI instead, a maintenance factor of MF = 0.80 must be considered.
In this case, by keeping the same support as that previously used and the geometrical characteristics, it is possible to get the following result:

Installation Type	MF	h p.l. (m)	I (m)	Carriageway	Bracket arm
unilateral	0.80	7	29	2 lanes 6.5m total	NO

LIGHTING ENGINEERING RESULTS

Lm [cd/m^2]	U_0	U_l	Ti (%)	S.R.
0.81	0.52	0.63	12.37	0.87

It can obviously be seen that the result is greater. In this case it is possible to calculate the IPEI parameter either by considering 100% of the flux and power emitted, or to forecast reduced operation thanks to the possible dimming of the LED diodes from the moment of operation startup (approximately 93%). As can be seen, thanks to the introduction of the correction factor k, both solutions show quite similar IPEI values.

1st case – calculation at 100% of the flux and power
The SLEEC is therefore calculated as: SL = 78/(29*6.5)/0.81 = 0.51
From the calculation we obtain k_{inst} = 1.04 and therefore an IPEI index = 0.51/0.58*1.04 = 0.91 (class A)

2nd case – calculation at 92% of the flux and 93% of the power (to obtain a L_m = 0.75 cd/m^2)
The SLEEC is therefore calculated as: SL = 73/(29*6.5)/0.75 = 0.52.
From the calculation we obtain k_{inst} = 1.00 and therefore an IPEI index = 0.52/0.58*1.00 = 0.90 (class A).

6. Conclusions

The economic crisis of the last few years has resulted in an inevitable cut in the spending dedicated to Public Lighting: gone is the time when tenders for new installations could be assigned on paper, without economic and energy evaluations. Today, Public Administrations want more than ever to be safeguarded on their investments and there can never be enough guarantees regarding the manufacturers' or the administrators' good work.

In a market with highly asymmetrical information like that of lighting, the most widespread instruments to convey missing information are the offer of guarantees and reputation: the certificates herein presented can offer the user both these solutions clearly and plainly. .

HERA Luce therefore wishes to act in advance of future legislative requirements and provide an objective common instrument that can clearly and thoroughly explain all the requisites concerning the management, performance and consumption of a lighting installation.

The advantages of this system are:

- the "translation" of technical data into easy-to-read pointers and thus useful information for Public Administrations;
- a simple, reliable system of certification with parameters that are easy to update, that can regularly be brought in line with the *Best Available Technologies* present on the market;
- the promotion, within the *Green Public Procurement* context, of excellent systems of illumination from the energy, economic e technological points of view;
- the definition of precise technical parameters for luminaires and installations that can guide the professional towards singling out the best product.

To reinforce the validity of the proposed system, we would like to underline that the layout of the HERA Luce classification is already aligned with the Green Procurement indications contained in the ministerial decree of 22 Feb. 2011, which states the minimum environmental criteria for public lighting.

The challenges of the future must be tackled today in order to guarantee the use of the best technologies and thus the maximum efficiency of Public Lighting installations.