CIELOBUIO – Coordinamento per la protezione del cielo notturno
presents:

VISUAL Accomplishment Regulations for the R. L. 17/00

Law of the Lombardy Region no. 17 of 03/27/2000

"Urgent measures to fight the light pollution and to achieve energy saving in the use of outdoor lighting "

Regional Council Decision no. 7/2611 of 11/12/2000

"Revision of the list of the astronomical observatories in Lombardy and determination of the relative respect zones"

Regional Council Decision no. 7/6162 of 09/20/2001

"Criteria for the enforcement of the R. L. no. 17 of 03/27/00"

Interpret, understand, know and examine in detail the R. L. 17/00 and the related deliberations

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October 2001

Criteria for the enforcement of the regional law March 27th, 2000, no. 17

Deliberation of the Regional Council No. 7/6162 of September 20th, 2001
As from the BURL n.40 Ordinary Series of October 1st, 2001
[Annex A - Law of the Lombardy Region no. 17 of 03/27/2000]
[Annex E - A Model for a new Light pollution Law similar to Lombardy Law]

1. Aim

The present technical provisions put into effect the directives of the regional law March 27th, 2000, no. 17, with which the Lombardy Region intended to confirm the ultimate objectives in theme of energy and environment: to rationalize and reduce the energy consumptions with wide breath initiatives which can stimulate the technological development, to reduce the light pollution on the regional territory and, as a consequence, to safeguard the ecological equilibria both inside and outside the protected natural areas and to protect the astronomical-, astrophysical- and scientific-observatories, as they are regional patrimony, to protect the activities of scientific research and divulgation.

The elaborated criteria, without detriment to the general determinations or claims more explicitly reported to the observatories, are oriented to the building of installations for the public and private outdoor lighting, characterized by illuminotechnical properties functional to control light pollution and to energy saving; for as it concerns the aspects connected to the plant engineering safety, please refer to the current directives in the field.

2. Fulfilments

The Region

- encourages the adjustment of the existing installations of outdoor lighting;

- updates the list of the observatories of which to the art. 10 of the r.l. 17/00 with the possible new observatories which apply for, also on proposal of the Italian Astronomical Union and the Italian Amateur Astronomer Union and determines the relative respect zones; to this purpose, the *pro-tempore* responsible of the observatory must transmit, to the competent Organizational Unity of the Regional Council, the following documentation:

[Annex B - Lombardy Regional Council Decision no. 7/2611 of 11/12/2000 "Revision of the list of the astronomical observatories in Lombardy and determination of the relative respect zones"]

a) the georeferential data concerning the location of the observatory;
[Annex C - List of the observatories, categories and reference geographic coordinates]

b) a report on the typology of the observatory and on the relative instrumental equipment;

c) the annual or pluriennal scientific- and cultural- program;

d) the regulation for the access of the visitors and a report on the possible infrastructure to support them;

e) the report on the historical activity done (for the observatories in activity, which apply for inclusion in the official list);

f) color photos of environment, the landscape and the structure in his complex;

- identifies, by cartography in adequate scale, the zones of protection of the astronomical observatories, informing the interested municipalities, by delivering them copy of the documentation;

- issues these criteria for the application of the r.l. 17/00 and adjusts them in relation to the any new dispositions that should had to intervene, that is according to the necessity to adopt innovative technological solutions, in terms of energy saving and light pollution.

The Districts

- exercise the control on the correct and rational use of the electric energy for outdoor lighting and provide to divulge the principes dictated by the r.l. 17/00;

- edit and publish the list of the municipalities interested directly or indirectly by the presence of astronomical observatories, even if outside the administrative ambit of competence, as included inside the specified zones of protection;

- update said list according to the variations ordered by the Region;

[Annex D - Municipalities included into the protected zones]

The Municipalities

- adopt, within three years from the date of coming into effect of the r.l. 17/00, the plans of lighting which discipline the new installations, in agreement with the present criteria, the decree of April 30th 1992, n. 285 bearing the "New Code of the Road" and with the state laws January 9th, 1991, no. 9 and n. 10 on the "National Energetic Plan";

[Annex F - Lighting plans: an introduction]

- authorize, by act of the Mayor, the projects of all the installations for outdoor lighting, including those for advertising purposes, with the exclusion of those of modest entity, as those of Chapter 9), letters a), b), c), d) and e).
  To be authorized, the project must be drawn in conformity with the present criteria and therefore signed by a qualified technician skilled in the field, who will take the responsibility of the project itself.
  At the end of the works, the installer transmits to the town-council the declaration of conformity to the criteria of the R.L. 17/00 of the lighting installation and the certificate of test according to the law March 5th, 1990, no. 46 "Rules for the Safety of Plants and Systems" and next updatings; the care and the burdens of the tests are charged to the buyer of the systems;

[Annex H - Installation declaration of conformity to the R.L. 17/00]

- they agree with the observatories specific indications for the possible revocation of the exemptions concerning the light sources in the protected zones;

- arrange, through direct periodic controls or upon request of the astronomical observatories and of other scientific observatories, to guarantee the respect and the application of the r.l. 17/00 both by the public and private subjects, in their territorial competence;

- if necessary, issue appropriate decrees for the best application of the present criteria and to contain the light pollution and the energy consumptions connected to outdoor lighting, with specific indications for the release of the building licences;

- arrange, also upon request of the astronomical or other scientific observatories, for the verification of the light sources not responding to the requirements of the present criteria, ordering for the modification, the replacement or the normalization of said light sources, within one year from the notification of the recognized irregularity, and, expired said time, within sixty days without any further delay;

[Annex G - Violation Assesment Form R.L. 17/00]

- provide, through the commands of municipal police, to identify the lighting devices dangerous to the road circulation, as responsible for dazzling phenomena to the vehicles in transit, and dispose immediate normalization interventions according to the present criteria;

- adopt integrally, by suitable regulations, the criteria required for the protected observatories, even if the municipality is not included into the protection zones, but as autonomously oriented to get the same aims;

a) apply, where indicated, the administrative endorsements according to article 8 of the R.L. 17/00, employing of the corresponding proceeds for the aims of the same article.

The astronomical observatories

- report to the competent territorial authorities, and in the first place to the town councils, the presence of sources of light not in conformity with the present criteria requiring their intervention to modify or replace or in any way harmonize such lights to said criteria;

[Annex G - Violation Assesment Form R.L. 17/00]

- collaborate with the Town Councils, the Mountain Communities and the Provinces, let alone the Region, for a better and punctual application of the present criteria, according to their specific skills;

- require to the Town Councils, periodic controls to guarantee the respect and the application of the present criteria by public and private subjects, on their territorial competence ambits;

- require to the Town Councils, the verification, the removal and the adjustment of the light points not responding to the requirements of the present criteria.

[Annex G - Violation Assesment Form R.L. 17/00]

The manufacturing-, importing-, supplier-companies

- arrange to equip the technical documentation with the following documents:

a) the certificate of conformity to the r.l. 17/00, upon request of the planner, for the product put in work on the territory of the Lombardy Region;

[Annex I - Example of product conformity declaration to the Lombardy Regional Law n ° 17 of March 27th, 2000]

b) the photometric measurement of the device, both in numerical tabular form on paper support, and in standard normalized file, like the commercial "Eulumdat" or analogous format; said measure must include:

[Annex M - Photometric curves - how to read and understand them]

- the environment temperature during the measurement;
- the tension and the frequency of the power source;
- the reference rule used for the measurement;
- the identification of the laboratory which did the measure and the name of the technician in charge for;
- the specifications of the lamp (light source) used for the test;
- the position of the device during the measurement;
- the type of equipment used for the measure and the relative measure uncertainty;
- the declaration of the technician responsible for laboratory or of third corporations, i.e. IMQ, about the truthfulness of the measures.

The designers

- draw up and undersign the project, correspondingly to the present criteria, only as enabled technicians registered on professional orders, with specific curricula; as far as the design of the advertising signboards are concerned, the dispositions of the law 46/90 remain in force.

- require, at the manufacturer companies, importers and suppliers, for any product put in work on the regional territory, the certificate of conformity to the r.l. 17/00, to enclose in each project;

[Annex I - Example of product conformity declaration to the Lombardy Regional Law n ° 17 of March 27th, 2000]

The installers

- realize the installations correspondingly to the present criteria and apply to any product put in work on the regional territory, the adhesive label reading "optics anti-light-pollution and reduced energy consumption, according to the laws of the Lombardy Region";

- release the declaration of conformity of the lighting installation to the criteria of the r.l. 17/00.

[Annex H - Installation declaration of conformity to the R.L. 17/00]

3. Definition

The r.l. 17/2000 considers as light pollution of the atmosphere every artificial light irradiation that is dispersed outside the areas to which it is functionally dedicated and, in particular way, if oriented above the line of the horizon.

[Annex O - Glossary of Basic Terms and Definitions to Lombardy Law]

Fig.1 - Typical examples of unjustified dispersion of light upwards or where it is not required

4. Introduction

General directions

From the date of coming into effect of the r.l. 17/00, all the new installations of outdoor lighting, both public and private, which concern the whole regional territory, including those still in design or in contract procedure, must be realized according to the present anti-light-pollution criteria and reduced energy consumption.

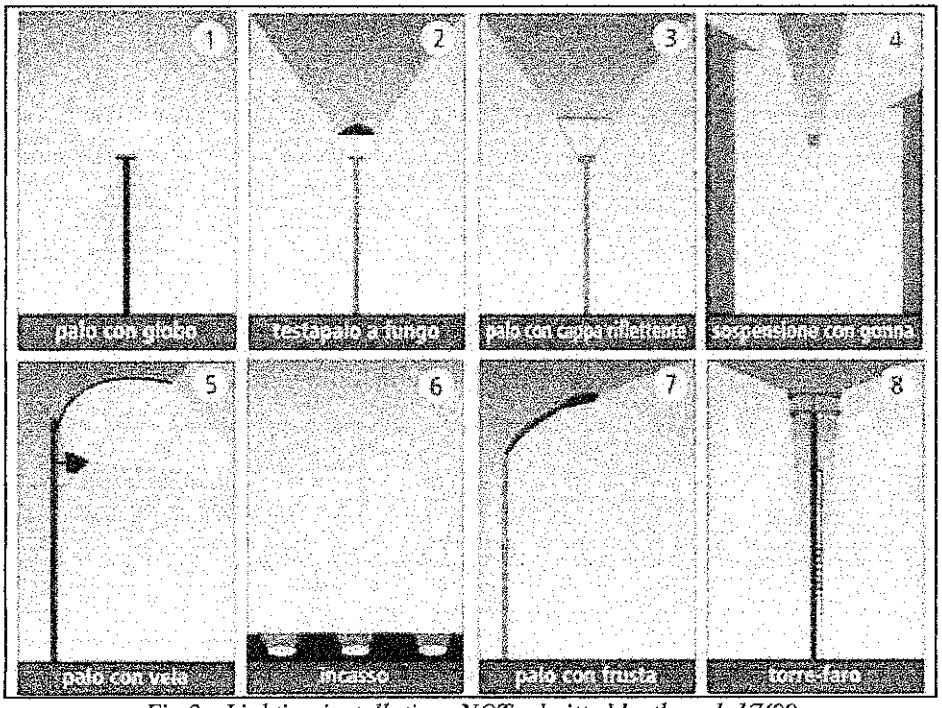

Fig.2 - Lighting installations NOT admitted by the r. l. 17/00

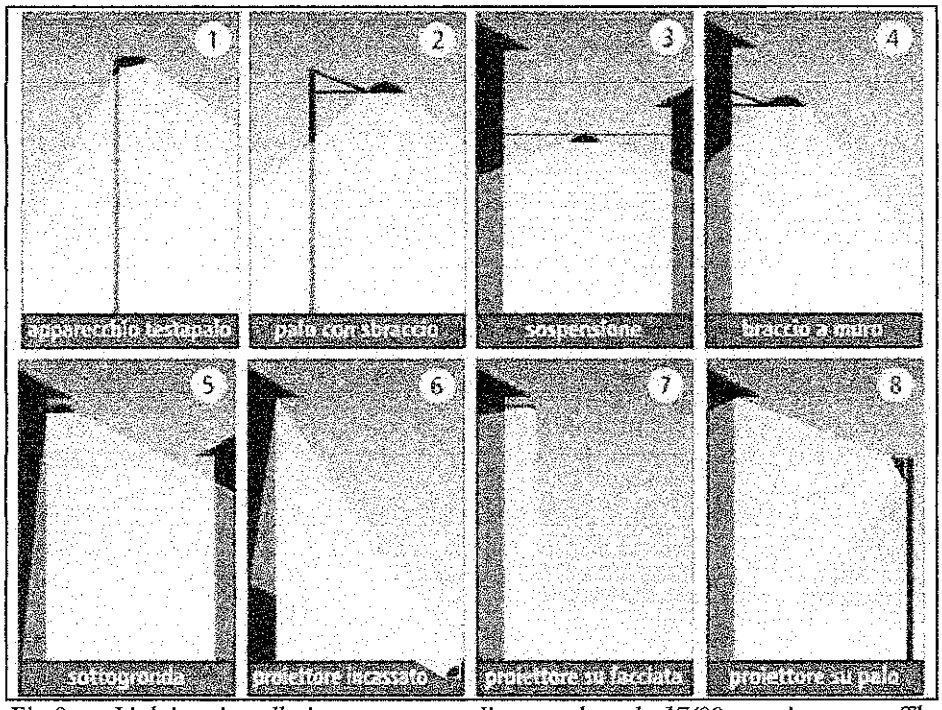

Fig.3 -- Lighting installations corresponding to the r.l. 17/00 requirements. The lighting devices as from points 6 and 8 are admitted by the r.l. 17/00 art.6 paragraph 10 exclusively for structures of particular and proved historical importance only if it is not possible light up them from upward.

All the specifications concerning outdoor lighting installations and devices, both public and private, must be corresponding to the r.l. 17/00 requirements and therefore, to the present criteria.

The installations already in phase of execution at the same date, must, if possible at once, be provided with systems and suitable precautions to avoid the light dispersion upwards, mantaining the obligation of their next adjustment according to the presents criteria.

For what concerns the existing lighting installations not in accordance with the present criteria, the normalization must be completed within 18 months from the coming into effect of the r.l. 17/00, without prejudice to the safety requirements of current directives, by modifying the inclination of the devices to angles closer to the horizon line, when structurally possible, and inserting suitable shields to limit the light emission beyond 90°, if compatible with the requirements of electric safety.
[if this was not at all possible, no further adjustments are provided for]

Special provisions for the protected zones

All the light sources present in the observatories protected areas, which are not in conformity with the present criteria, must, within four years from the coming into effect of the r.l. 17/00, be modified to reduce both light pollution and the energy consumption by the use of high- and low-pressure sodium lamps, or lamps with similar efficiency, in relation to the best available technology;

[Annex D - Municipalities included into the protected zones]

[In chapter 8 we further clarify the interventions of adjustment on the installations and the devices which must happen with the same timing (4 years)]

5. Common criteria

The reduced energy consumption and anti-ligth pollution installations must own, simultaneously, the following qualifications:

a) fixtures which, in their installation position, must have a distribution of the maximum light intensity for gamma angles equal or greater than 90°, comprised between 0,00 and 0,49 candles per 1000 lumen of total light flow; to such a purpose, generally, the lamps must be recessed in the upper part of the fixture itself;

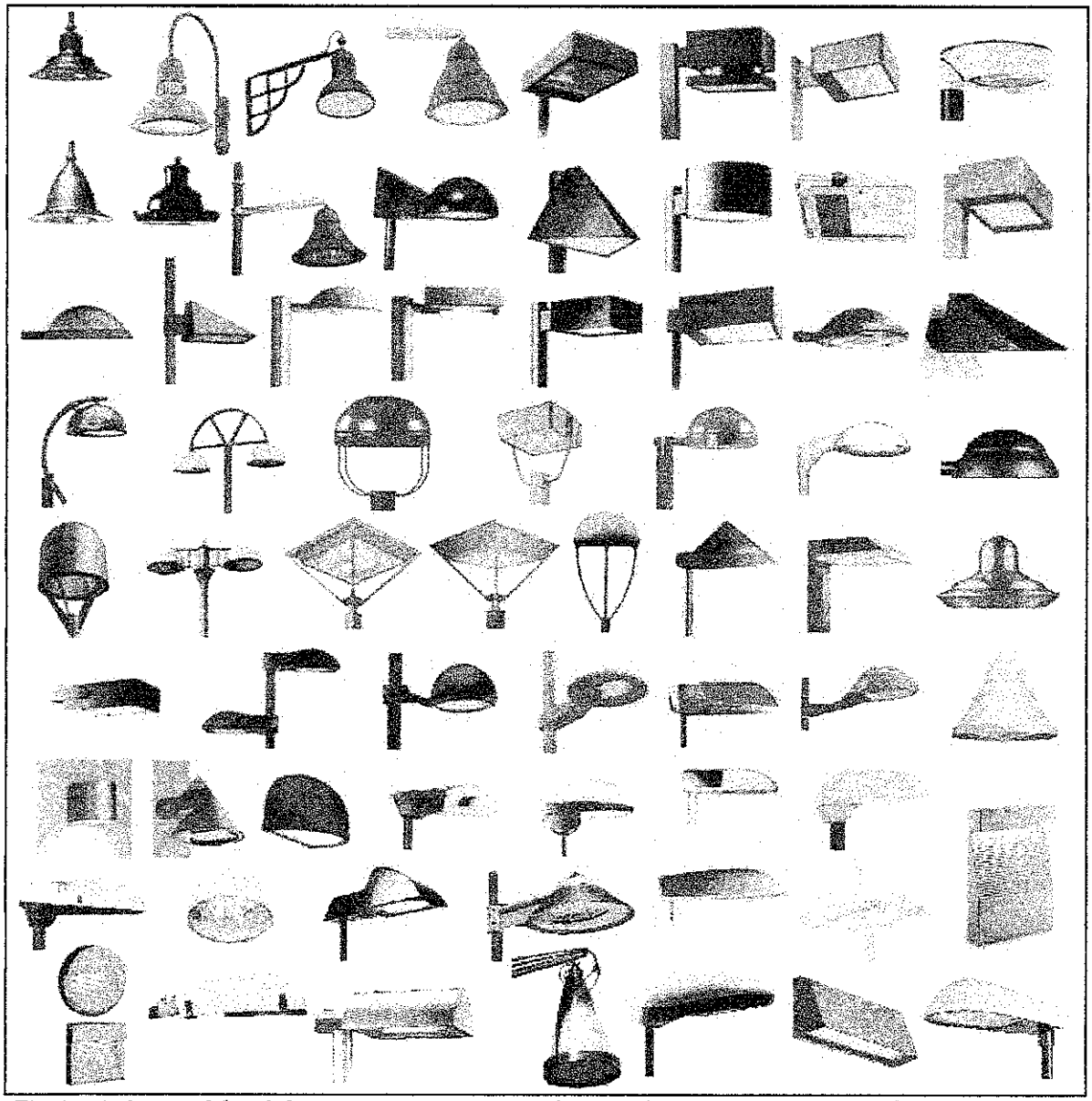

Fig.4 - A few models of devices corresponding to the R.L. 17/00 requirements. In the CieloBuio site: http://www.vialattea.net/cielobuio/prodotti.htm it is possible to access a photographic guide of products having good impact on light pollution. The relevant producers agreed to their publication. (Attention: not all of the products in the site are fully corresponding to the R.L. 17/00).

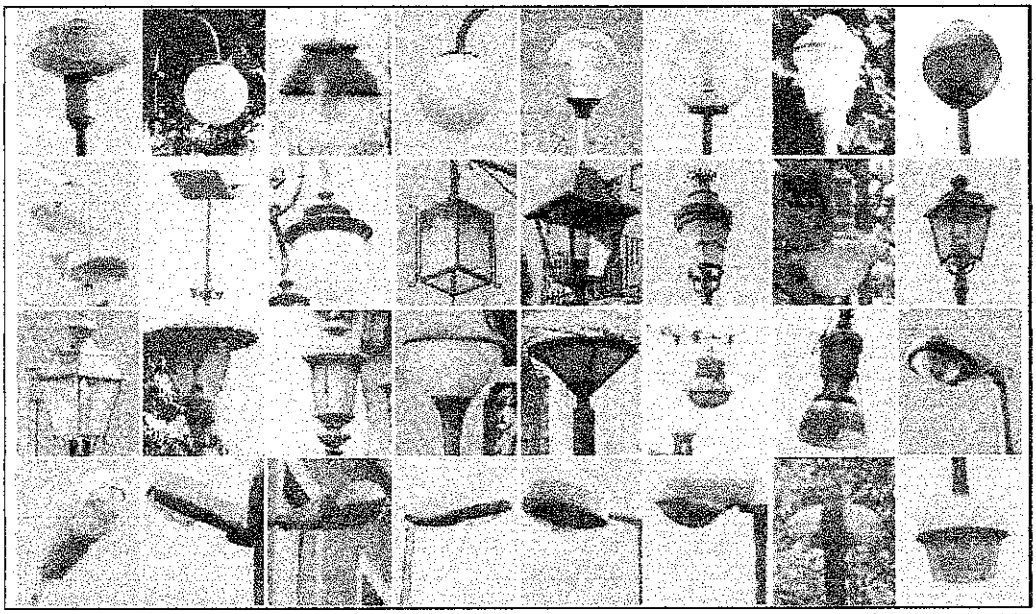

Fig.5 - Lighting devices commonly found in our towns not corresponding to the R.L. 17/00 requirements.

b) lamps of advanced technology and elevated light efficiency, such as low- or high-pressure sodium vapour lamps, instead of those with lower light efficiency. It is allowed the utilization of broad-spectrum lamps, metal-halide lamps, fluorescence and sodium-white-light lamps, only in cases where it is indispensable to achieve an elevated chromatic yield, provided that such lamps are functional in terms of highest efficiency and lowest installed power;

Efficiency of Light Sources in 1998

Type of Lamp	Lumens per watt	Average Lamp Life (Hours)
Incandescent	8 - 25	1000 - 2000
Mercury Vapor	13 - 48	12000 - 24000+
Fluorescent	60 - 110	10000 - 24000
Metal Halide	60 - 100	10000 - 15000
High Pressure Sodium	45 - 110	12000 - 24000
Low Pressure Sodium	80 - 180	10000 - 18000
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[Annex N - Efficient Outdoor Lighting]

c) lamp-protection elements preferably transparent and flat surfaced, realized with stable-, no staining-material such as glass, methacrilate and others with similar properties;

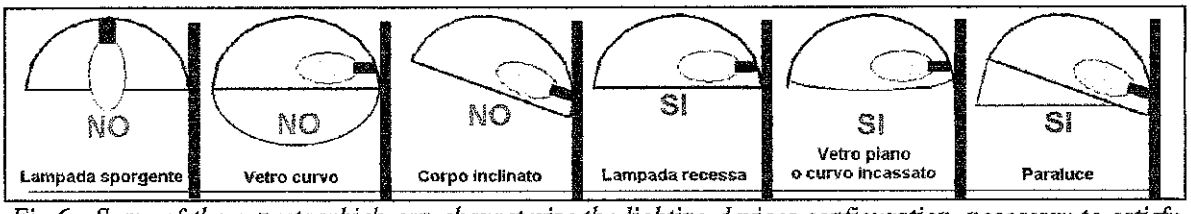


Fig.6 - Some of the aspects which can characterize the lighting devices configuration, necessary to satisfy the requirements of the L.R.17/00

d) maintained average luminance of the surfaces to be illuminated not higher than the minimum levels required by the safety technical rules or by the present criteria, according to the following guidelines:
   - calculation of the luminance in function of the type and the colour of the surface;
   - utilization, luminance being equal, of devices whit reduced electric power demand and optimum conditions of light points interdistance;
   - maintenance of homogeneous luminance values on all the illuminated surfaces, not higher than 1 cd/m^2, without prejudice to any safety disposition;
   - use of devices able to reduce, within the hours 24.00, the light emission by at least 30% with respect to the full regimen of operativity, provided that safety is not compromised;
   - choice of installations with greater utilization coefficient ;
   - duly realization of installations, as indicated by the CEE Directives, National provisions and DIN, UNI, NF, etc. norms assuming, conditions being equal, the normative references which compete for the minimum level of maintained luminance.

6. Criteria for specific plants

For the following installations categories, the following criteria must be also applied, integrating what devised in Chapter 5.

Extra-urban installations

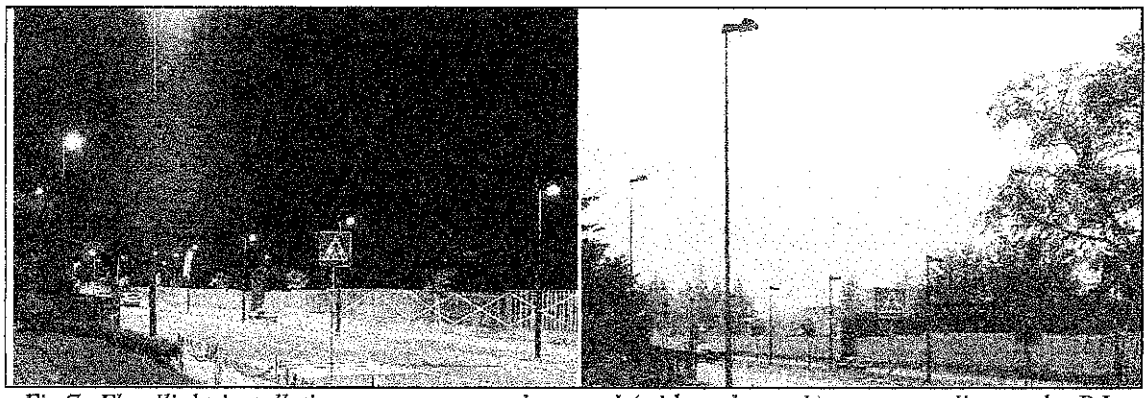


Fig.7- Floodlight installations on an extra-urban road (with cycle track), corresponding to the R.L. 17/00 requiremetnts and realized in Usmate after the approval of the R.L. 17/00

The lighting of motorways, highways, traffic circles, etc. must be guaranteed preferably employing low-pressure sodium lamps; if necessary, analogous high-pressure lamps are allowed.

Large surfaces

The lighting of car parks, squares and other similar large surfaces must be guaranteed preferably employing low- or high-pressure sodium lamps;

Fig.8 - Left and right, two car parks corresponding to the R.L. 17/00 requirements; center, one with spheres partly screened, in any case not corresponding to the R.L. 17/00 requirements.

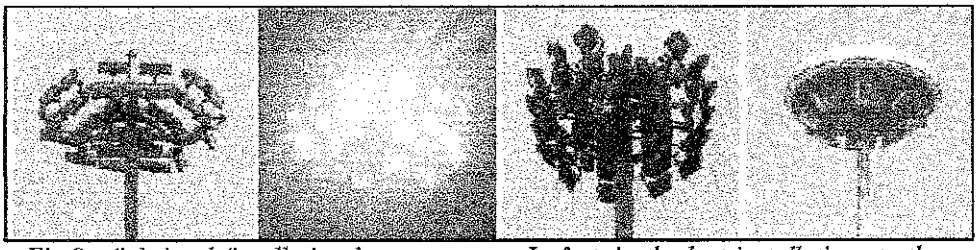


Fig.9 - "obviously" polluting beacon-towers. In fact, in the last installations to the right, the upper cover has the only purpose to protect the lighting devices from bad weather.

In the periods of not utilization, the lighting installations must be provided with suitable systems to switch them off or to reduce the luminance.

In the installation of beacon-towers, the installed power must be lower than that of a plant with traditional devices, luminance of the surfaces lit up being equal, that is if the utilization factor exceeds the value of 0,5, reported to the only road surface.

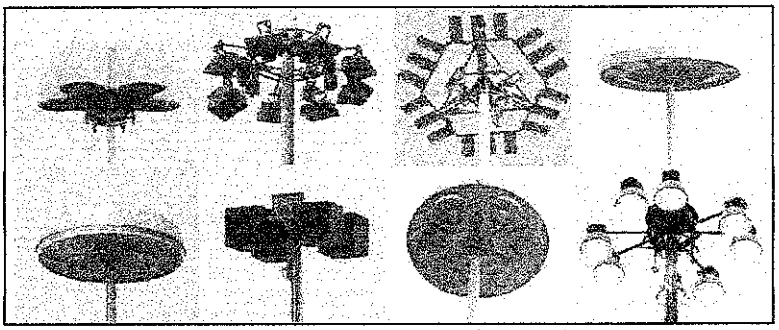


Fig.10 – Beacon-towers corresponding to the R.L. 17/00 requirements.

Historical city-centers and commercial streets

The lighting installations, in the presence of plantations, must be positioned so as to avoid that the flow towards the surfaces to be lit up is significantly intercepted by the canopy of the trees themselves.

The lighting of the old cities centres must give preference to devices positioned under eave or directly on the wall.

Fig.11 – Left:Dalmine City Hall Square. Lighting corresponding to the R.L. 17/00 requirements and light sources placed so as not to interfere with the trees canopy. Right:Two examples of lighting of old cities centres with devices under eave (in the image to far right a horizontal device put beside to an inclined one which instead disperses light upwards).

7. Criteria for other specific lighting installations

Sports arenas and buildings

The lighting of such plants, by beacons, beacon-towers and projectors, must be realized according to the general indications devised in Chapter 5.

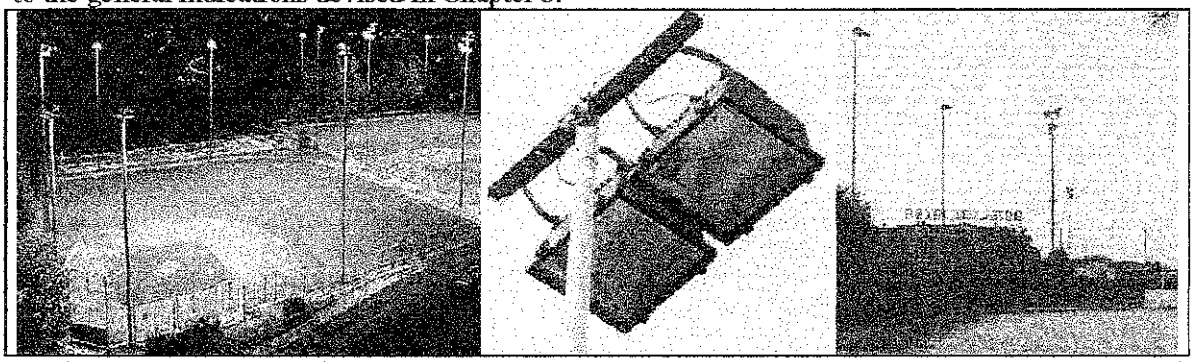
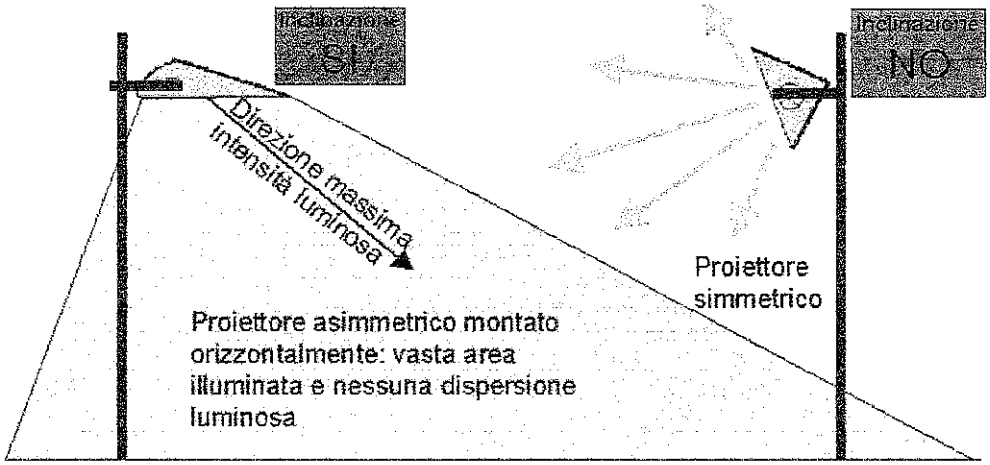


Fig.12 - Sporting plants lightings corresponding to the R.L.17/00 requirements, with asymmetrical floodlights oriented horizontally and not dispersing light above the horizon.

The same must be guaranteed with the use, preferably, of high-efficiency lamps; if it is necessary to guarantee a high chromatic yield, metal-halide lamps are allowed.

The installations must be equipped with suitable variators of the luminance in relation to the activities/events, i.e. trainings, competitions, televising and others.

The floodlights must be of the asymmetrical type, with such an inclination to restrain the dispersion of light beyond the area destined to the sporting activity.



[Symmetric and asymmetric devices if placed horizontally and with flat protective glass are equally conform to the R.L. 17/00]

For the sporting plants of large dimensions, where televising is planned, it is agreed to use, further to the asymmetrical projectors, even narrow-beam projectors in any case equipped with shields or fins to avoid the dispersion of the light beyond the appointed areas.

In the lighting of the skiing tracks, the light dispersion beyond the same track must be strictly limited; the calculation of the luminance must be correlated to the high index of reflection of the snow. The installations must be turned off within the hours 21.

Monuments and buildings

The lighting of such structures, mantaining the general indications of which to Chapter 5), must be, preferably, of grazing-, bottomwards type; only in cases of real impossibility and for subjects of particular and proven historical value, the beams of light can be differently oriented, remaining, any way, at least one meter under the upper edge of the surface to be illuminated and, in any case, within the perimeter of the same building or monument, arranging for the partial or total switching off, or for the decrease of absorbed power, within the hours twenty-four.

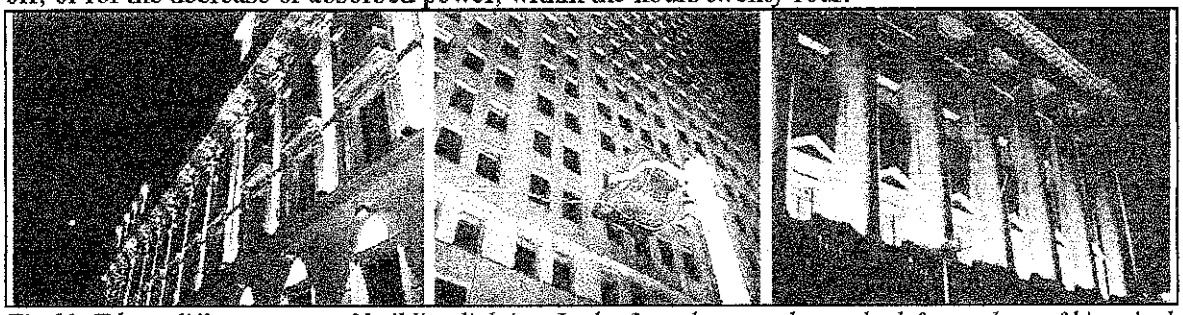


Fig.13 -Tthree different cases of building lighting. In the first photography on the left, a palace of historical value with mixed lighting, bottomwards and within the outline of the building (thus corresponding to the R.L.17/00 requirements), and topwards (not corresponding). In the second photography a building of none artistic, historical, military interest or used for the administration of the justice lit up topwards with high installed power without any reason. In the third photography, the lighting of the building of high historical and artistic value, is done topwards keeping the light within the outline of the building as itself as specified by the R.L. 17/00, but with an excessive installed power any way.

The installations must use optic able to collimate or shape the light beam (i.e. using spot projectors) and be equipped with possible shields to avoid or limit the light dispersion.

The mantained average luminance must not exceed that of the surfaces lit up in the surrounding areas, such as roads, buildings or other and, in any case, be contained within the mean value of 1 cd/m^2.

The lighting of the industrial sheds must be made using preferably low-pressure sodium lamps.

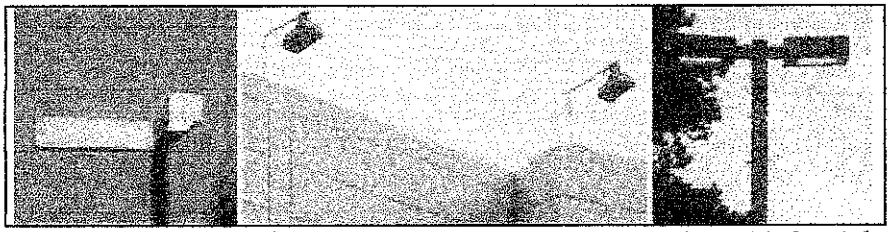


Fig.14 - The figures show some devices for road , car parks and industrial sheds lighting. The lamps used are full cut-off, low-pressure sodium equipped with horizontal flat glass.

In the illumination of buildings without any historical value, high-efficiency lamps, such as high-pressure- or low-pressure sodium lamps are to be preferred; in alternative, also installations equipped with movement sensors for the switch on can be used. Control devices for the partial or total switching off, or for the decrease of used power within the hours twenty-four, must be taken into consideration.

Signboards without its own lighting

The lighting must be realized top-down, as defined in Chapter 5, "Common criteria".
Also the signboards with external sources of light belong to this category.

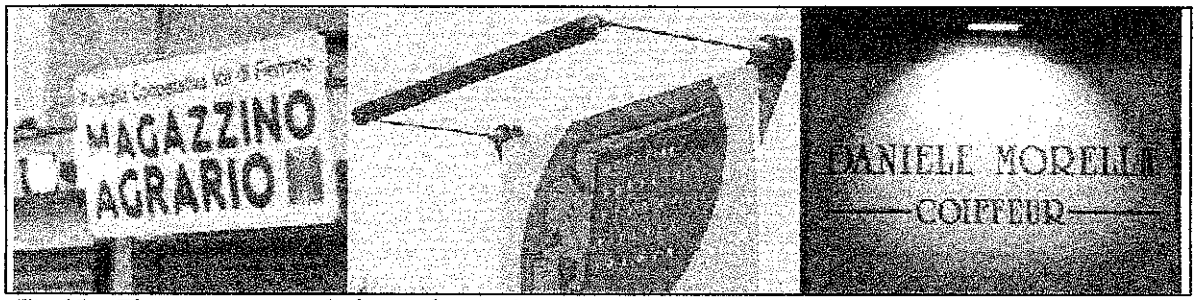


Fig.15 - Three manners to light up the signboards. In the first (side lighting - photography on the left) lightening topwards is avoided, but still half of the light it is however dispersed towards the upper direction. In the second, even if the lamps are screened by the protective shell (partially visible) part of the light goes out beyond the upper edge of the road panel. And at last the third installation is undoubtely a correctly illuminated business signboard, according to the R.L. 17/00 requirements (overhead lighting).

8. Additional directives for the protected zones

The installations included in such territories, keeping in mind the general dispositions for the adjustment of the existing ones at the date of coming into effect of the law 17/00 and already shown in Chapter 4, and the qualifications of which to Chapter 5, must also conform to the following supplementary criteria:

[In this chapter are clarified the types of interventions to be done on installations and devices with the same timings shown in Chapter 4 (4 years), except where differently stated]

a) the change of the inclination of the public and private devices must be carried out within six months from the date of coming into effect of the r.l. 17/00, since it is compatible with the technical safety measures, if any;

b) the adjustment of the private installations of outdoor lighting can be carried out with the installation of suitable shields, or by the replacement of the protective caps, or of the lamps themselves, in accordance with the qualifications of electric safety;

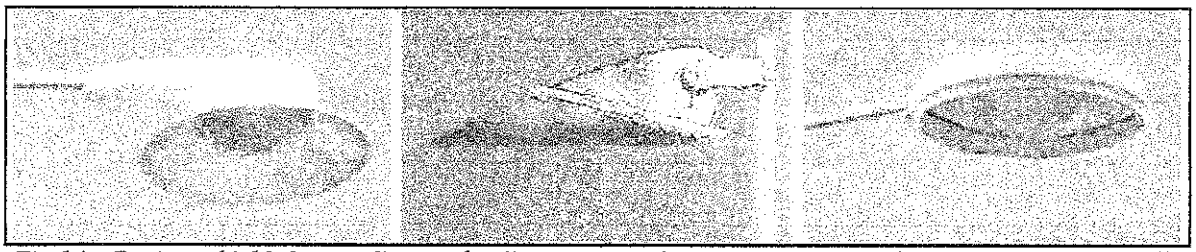


Fig.16 - Devices shielded according to the directives for the protected zones. These are devices normally considered NOT conform (prismatic cups and inclined projectors) - Courtesy: International DarkSky Association.

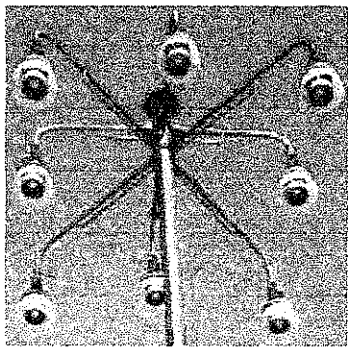
c) the replacing lamps must be high- or low-pressure sodium vapours; only in case of material impossibility the use of different lamps is allowed, provided that they have an analogous efficiency, in relation to the state of the technology;

d) the public installations of outdoor lighting must be conformed by the total replacement of the devices, if it is not possible to change the inclination or to replace the protective shells;

[The replacement must be done using devices which respect the "common criteria" as from Chapter 5, except what indicated in the following point f)]

e) all the installations of outdoor lighting, already existing at the date of coming into effect of the r.l. 17/00, where it is possible to keep the minimum safety levels, if any, may be partialized at 50% (instead of using flow reducers), within the hours 23.00 in the period of regular time and the hours 24.00 in the period of day-light saving time;

f) the highly polluting lighting devices, such as globes, globes with shielding fins, indirect light systems, lanterns or similar, already existing at the date of coming into effect of the r.l. 17/00, must be shielded and, in any case, equipped with suitable devices able to contain and direct in the upper hemisphere a maximum light intensity never larger than 15 cd per 1000 lumen at 90° and beyond, and equipped with transparent protective glasses, compatibly with the qualifications of electric safety. If such measures cannot be realized, the devices must be replaced with others having the qualifications of which to Chapter 5;



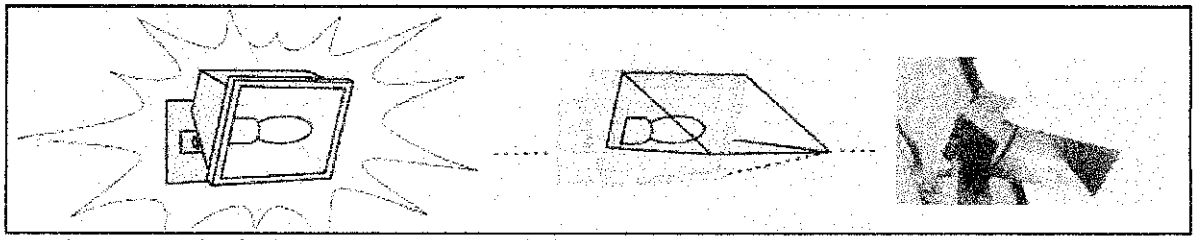


Fig.17 - A simple shield to avoid undesired light and directed towards the sky. In the above image, an example of adjustment to the.R.L. 17/00 requirements performed at the Railway Central Station of Milan: an aluminium cup has been inserted between the bulb and the protective opal glass to avoid light dispersion.

g) the new lighting installations must own the qualifications indicated in Chapter 5 and must be equipped only with high- or low-pressure sodium lamps, or, in case of material impossibility, with lamps having analogous efficiency, and with regulators of light flow;

h) all the signboards of any type, of not specific and indispensable nocturnal use, must be shut off within 23.00 hours in the period of day-light saving time and 22.00 hours in the period of regular time; all others within the relevant closing time.

9. Exemptions

Exemption to the present criteria is granted for:

a) all the internal light sources and therefore not polluting, such those inside the buildings, in the subways, the tunnels, and like structures shielding the dispersion of the light upwards;

Fig.18 - Four examples of internal lights: inside buildings, under arcades and in tunnels (pedestrian or road)

b) the sources of light with emissions not higher than 1500 lumen each (intended as the total flow emitted by the source in every direction) in installations of modest entity, that is made up by a maximum of three centers with a single light point. For installations with more than three light points, the expemption is granted only if the fixtures are equipped with suitable shields to contain the light flow altogether within 2250 lumen at 90° and beyond, without detriment to ties of the single light point and of the single source emission, in every direction, be not higher than 1500 lumen;

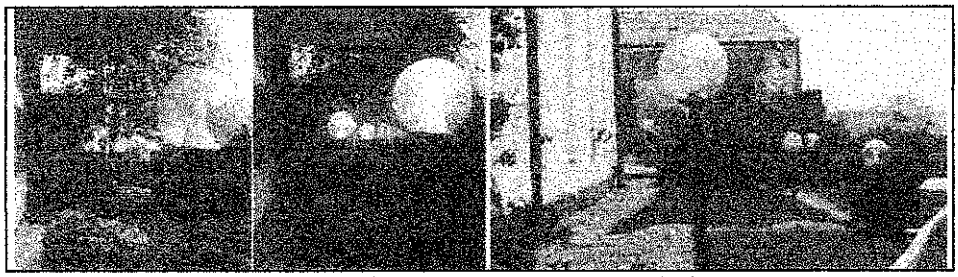


Fig.19 - In the two photos on the left, the lighting is in accordance with the exemption for 3 not shielded light points of max 23 W fluorescence lamps. In the right image however the exemption may be granted only if the 5 devices (light points) were each equipped with max 23 W fluorescence shielded lamps (thing which does not happen) so that the maximum emission at 90° and beyond does not altogether exceed 2250 lumen.

c) all those sources of light of temporary use or that are turned off within 20.00 hours in the period of regular time and 22.00 hours in the period of day-light saving time, such as i.e. halogen projectors, fluorescent bulbs or other, regulated by a presence sensor;

d) the advertising signboards of modest entity, not equipped with its own lighting, such as:

- the business signboards, as indicated in art. 23 of the "New Code of the Road" and related Accomplishment Regulations, and those with surfaces not larger than 6 squared meters, in any case with top-down light flow, in order to get the light intensity within the terms of Chapter 5;

Fig.20 - On the right a business signboard which does not need neither a specific project nor the authorization of the Mayor, even if its conformity to the technical prescriptions (0 cd/klm at 90° and beyond) must be verified. In this case the inclination, not very conform to the R.L. 17/00, could be compensated by the shielding effect of the terrace. In the left image, another type of signboard (corresponding to the R.L. 17/00 requirements, since it is correctly illuminated) that requires a specific project and the authorization of the Mayor, being larger than 6 squared meters.

- all the devices of shop windows external lighting, for a number not higher than three shop windows, with light flow in any case directed top-down, in order to get the light intensity within the terms of Chapter 5;

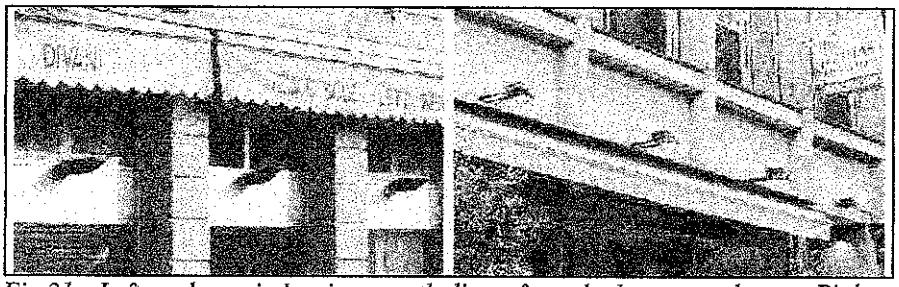


Fig.21 - Left: a shop window incorrectly lit up from the bottom to the top. Right: the lighting is corresponding to the R.L. 17/00 requirements. If the right shop window was truly conform, it would not need neither a project nor authorization by the competent authority.

e) the signboards equipped with its own lighting systems, even if made up by uncovered neon pipes;

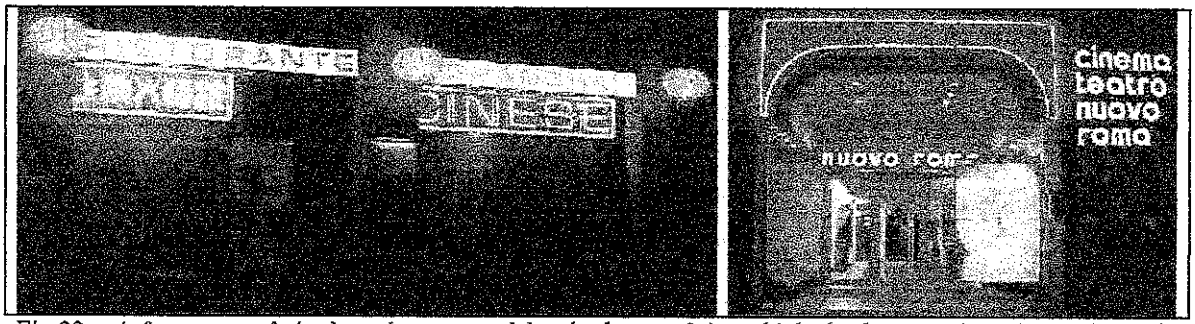


Fig.22 - A few types of signboards exempted by the law and for which the law requires, but only in the protected zones, only the switching off after 23.00 hours or at the time of closing of the exercise. It is possible to see: boxed letters with their own lighting (the cinema inscription), uncovered neons (entry decoration at the cinema and inscription in Chinese), or panels with internal lighting (the inscriptions restaurant and the playbill of the cinema).

f) all those light sources for which the replacement is planned within four years from the date of coming into effect of the r.l. 17/00;

g) the structures in which activities concerning the public order, the justice and defence administration are practised, as far as the reduction of the electric consumptions is concerned.

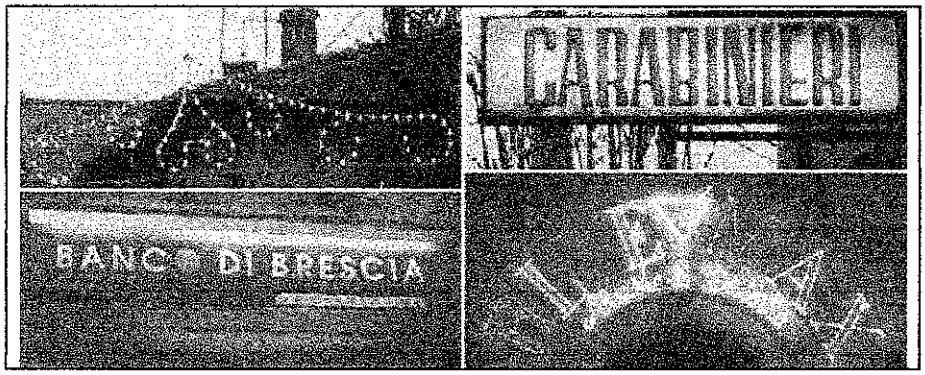


Fig.23 - A few types of advertising lightings.
Upper left: Christmas illuminations. Such signboards of temporary use (very limited in time) can be installed since expempted by the R.L. 17/00.
Upper right: Carabinieri's signborard in exemption by the law as pertaining to a structure in which public order is practised (exempted also for the switching off as from art.8, letter h) of the present regulations).
Lower left: Interesting lighting totally shielded and with low lighting values, more than sufficient for the purpose it is intended for.
Lower right: business signboard in exemption by the law since of the kind not illuminated from the exterior; however, this kind of signboard must be shut off if in the protected areas around observatories, according to art.8, letter h) of the present regulations).

The revocation of the above exemptions, inside the protected zones, results from specific indications agreed upon between the interested municipalities and the observatories.

To get the authorization of which to the art. 4, comma 1 – letter b) of the r.l. 17/00, the exemption as from letter d) is limited only to the design.
In any case, all the signboards must be switched off, as indicated in Chapter 8, letter h).

Fig.24 - Lighting (by night and during the day) of flowerbeds and gardens with installations corresponding to the R.L.17/00 and related Accomplishment Regulations.

10. Prohibitions

It is forbidden on the whole territory of the Lombardy Region the use rotating or fixed beam-lights or beacons of whichever type, for the mere advertising aim.

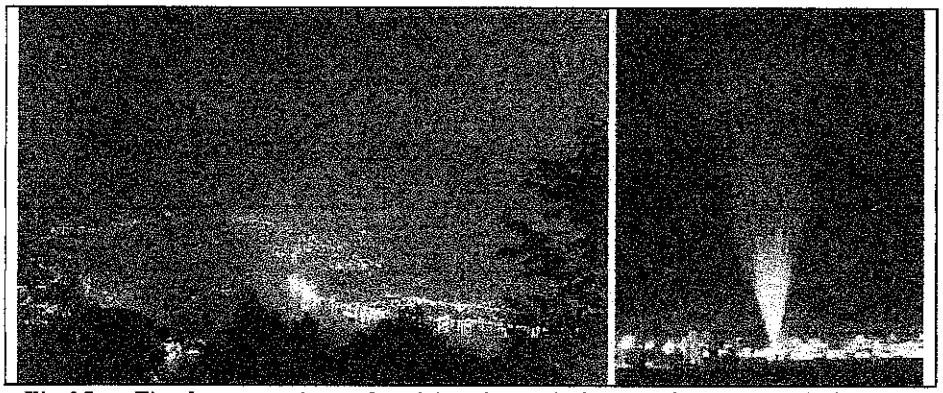


Fig.25 - Fixed or rotating advertising beam-lights. Such types of lighting are absolutely forbidden on all the regional territory. In the same way, any other types of advertising light calls not belonging to the signboard category as analysed in the exemptions of Chapter 9, such as illuminated montgolfiers or airships, light inscriptions projected in sky or the like, are absolutely forbidden too.

[Annex L - Example of Town-council's ordinance for the switching off of advertising light beacon as advertising "lasers"]

Annex A

Law of the Lombardy Region no. 17 of 03/27/2000
"Urgent measures to fight the light pollution and to achieve energy saving in the use of outdoor lighting "

ILLUSTRATIVE REPORT ON THE PROPOSAL OF REGIONAL LAW:
"URGENT MEASURES TO FIGHT THE LIGHT POLLUTION AND TO ACHIEVE ENERGY SAVING IN THE USE OF OUTDOOR LIGHTING"

1. PREMISE

Due to the excess of public and private lighting, it is more and more difficult to find places, in our province, where the dark is such to allow an adequate vision of the celestial vault: on average only 10% of stars are by now visible on the territory, especially in the greater centres. We remain therefore deprived of the biggest natural show: the observation of the universe!
Uncontrolled wide-spreading of light pollution constitutes, as we will see, an unjustified energy waste, an alteration of the equilibrium of the ecosystem and an impediment, *de facto*, to the observation of the sky. Some studies made clear the disturb to the fauna and to the flora due to the lack of day-and-night alternation in the zones too much illuminated; as an example the damage to migratory birds is intuitive, since they use stars in order to orientate in the nocturnal flight. In the recent Italian legislation, a precise reference is made to the necessity to prevent the light pollution: in the law on the protected natural areas - law of December 6, 1991, n. 394 -, where, in the article 11, the " light emissions" are indicated among the items that the park must discipline, in order to guarantee the pursuing of the conservation purposes and preservation of the natural patrimony. Also from a touristic point of view, the impact of highly illuminated areas is surely negative; to illustrate a real-life situation, the superb sceneries of ours Dolomiti must be protected also from this kind of pollution.
At the Conference of Paris, in June 1992, the UNESCO evidenced the enormous damage brought to astronomy by an excessive artificial illumination and declared the starry sky "Patrimony of the mankind", to be protected for the future generations.
In our region numerous astronomical associations are active, and dedicate their energies, with passion and engagement, to the popularization of astronomy, both to the large public and in the schools (from the first classes to the University of the Third age), and play a role also in the official scientific research; these activities endure heavy limitations due to uncontrolled spreading of the light pollution; this cultural patrimony must be therefore effectively protected.

2. THE LIGHT POLLUTION: CAUSES AND REMEDIES

The light pollution is due to the dispersal in the sky of the brightness produced by the lights of towns and cities. The origin of the problem depends on the fact that often the planning of the lighting systems and the design of the points of light, does not keep into account the possible light dispersions outside the area to be illuminated. The absence of a legislation on this matter favours in fact the uncontrolled (and a sometimes counter-productive) floodlight, and a consequent waste of energy, by private and public agencies and single citizens. According to data supplied from the International Dark Sky Association (Tucson, Arizona USA), and confirmed also in Italy by recent studies of the Italian Astronomical Society (S.A.It.), more than 30% of the public illumination is dispersed towards the sky, leading to a huge squander of public money, an irreparable damage to the astronomical research and culture and to the nocturnal image of the district. The importance of the astronomical research is demonstrated by the grants dedicated by all the industrial countries, Italy included. It has to pointed out that many lighting systems are now obsolete, since they are

still based on incandescence or mercury vapours lamps, highly polluting on all the visible spectrum; these last ones must also be considered "special wastes", being highly toxic, with higher disposal costs. In local realm, the problem is even more aggravated by the installation of rotary advertising beacons useful, perhaps, to few privates but surely harmful for the entire collectivity forced to endure, without any advantage, a new type of landscape degradation. Moreover, such beacons deliberately violate the Art. 23 of the New Code of the Road which prohibits, for safety reasons, their use and installation. **It is however important to point out that the problem of the light pollution is technically solvable, without compromising the right of the citizens to have the roads illuminated in an adequate way.** As an example, lamps habitually employed can be replaced, where possible, with high efficiency lamps like high-pressure sodium vapours lamps, less polluting and more efficient; the light dispersions could moreover be limited by use of full cut-off (totally shielded) systems or with asymmetric lamps equipped with appropriated shielding, directing the light with the right angle, from the high towards the bottom (avoiding therefore the floodlights inserted in the pavement). Equally important would be to adhere to the luminance values indicates in the directives and not to double or triple them without necessity. The suggestions are numerous and even the manufacturers of lighting systems offer, in their catalogues, some solutions provided that someone demands to them. **Such situation is placed in evident violation of the norms that impose suitable and opportune methods in order to contain the energetic consumption within acceptable limits,** dictated by the criterion of the real and consistent requirement (see the Italian Law n°10/1991 "Rules to actuate the National Energetic Plan for a rational use of energy, for energetic saving and development of the renewable sources of energy ").

The damage deriving from and uncontrolled use of electric energy is quantified every year in Italy in approximately 300-400 billion Liras (LIT), (estimation made for year ' 96, with annual increases of approximately 10%); with due calculations it is possible to deduce the economic damage for our district. Studies carried out by S.A.It. have shown that in medium-sized cities (approximately 50,000 inhabitants), savings for approximately 250 - 300 million Liras can be achieved, by means of a rational use of the energy in the public lighting only, diminishing at the same time the levels of light pollution and realizing also a fuel saving and consequently a lower emission of carbon dioxide (CO^2) into the atmosphere, the major responsible of "greenhouse effect". It can be calculated that the hypothetical discouragement of the light pollution on the whole Italian territory will lead to a saving of 430,000 tons of fuel in a year; consequently 1,356,000 tons of carbon dioxide would not be released, 1,480,000 tons of oxygen would not be burnt. From these considerations it is possible to confirm the importance and the urgency to approve a regional law that disciplines the lighting systems, both publics and private. It has to be observed, finally, that reducing the light pollution by the adoption of more modern planning criteria, means also to get cities better illuminated: in fact, avoiding that a part of light produced by the illumination systems goes dispersed towards the space, means to make it immediately available for a better visibility of the objects on the ground.

3. THE PROPOSED LAW: A SHORT COMMENT

The present law proposal is based on the one recently promulgated in Lombardy considered the best one among those approved up to now, according to those people who takes care the prevention of the light pollution. It is particularly effective in placing strict limits to the light dispersions. There are other regions that have been equipped with a law on lighting, e. g. Veneto, Tuscany, Lazio; in others the norm is still in phase of proposal. The approval of the present provision would allow Lombardy to overwhelm the legislative delay in this field.

Any modification, suggestion or adjustment of the present text has been done in agreement with the Coordination of the Astronomical Associations of Lombardy and CieloBuio; the law proposal is constituted from 12 articles.

Main aims are:
art.1 - the control of the energy consumptions deriving from the use of outdoor lighting systems, either public and private, the adequate choice of light sources and the protection of Astronomical observatories sites of regional and provincial importance, the reduction of light pollution on the provincial territory.
art.2 introduces the national laws which inspired the present law and the tasks the Region must assume in order to observe and to make the law observed.
art.3 characterize the delegations to the Regional Administration: address, promotion, advising and coordination, as well as dissemination of the general principles of the law and control on its application in the regional territory. The Region is also called to divulgate the knowledge of the principles of the law as well as, if there exists a protected Observatory in their territory, to compile the directory of the Municipalities which must conform to said law in due time.
art.4- the municipalities must adopt a plan for the lighting, in agreement to the present law, and guarantee its application and observation; they issue decrees in order to uniform the sources of light and apply the administrative endorsements, according to **art.8**, to not complying people and entreprises.
art.5 supplies directives about the protection of astronomical observatories of regional and provincial importance, which are called to monitor the zones of respect, pointing out illegitimate light sources.
art.6 provides specific standards, to be applied on the whole regional territory, to which constructors, importers and suppliers of lighting system and material will have to conform. New directives to correctly lighting monuments, railway and streets, parkings and sport arenas, are given.
art. 9 gives provisions to be adopted in the protected areas, determining of the "zones of respect". In order not to leave an empty normative the zones of respect for professional observatories have been indicated.
art.10 lists to the observatories and the sites to be protected. Such directory will regularly updated according the previous **art.5**.

"URGENT MEASURES TO FIGHT THE LIGHT POLLUTION AND TO ACHIEVE ENERGY SAVING IN THE USE OF OUTDOOR LIGHTING"

Article 1
(Purpose)

1. The present law, according to what established in the article 3, paragraph 3, points 7, 8, 9 of the Statute of the Lombardy Region, has for deriving purposes the reduction on the regional territory of the light pollution and the energy consumptions deriving from it, and consequently the protection of the activities of scientific research and popularisation carried out by the professional astronomical observatories of regional or provincial importance or other scientific observatories as well as the conservation of the ecological equilibriums either inside or outside the preserved natural areas.
2. (To the aims of the present law) it is considered as light pollution of the atmosphere every artificial light irradiation that is dispersed outside the areas to which it is functionally dedicated and, specifically, if oriented above the line of the horizon.

Article 2
(Tasks of the Region)

1. In order to actuate the National Energetic Plan the Regional Council stimulates the adaptation of the existing installations of outdoor lighting also in relation to the laws of January 9, 1991, n. 9 ("Rules to actuate the National Energetic Plan: institutional aspects, hydro-electric power plants and electric pipelines, hydrocarbons and geothermic, self-production and fiscal provisions") and of January 9, 1991, n. 10 ("Rules to actuate the National Energetic Plan for a rational use of energy, for energetic saving and development of the renewable sources of energy ").
2. All contracts and their specifications relevant to the public and private lighting must be consistent with the aims of the present law.

Article 3
(Tasks of the Districts)

1. The Districts (provinces):
a) do exert the control on the correct and rational use of the electric energy for outdoor lighting and provide to divulge the principles dictated in the present law;
b) do provide for the drawing up and the publication of the directory of the municipalities in whose territory there exists an astronomical observatory to be protected; such directory includes also the municipalities outside of the district territory, on condition that they are inside the specified zones of protection.

Article 4
(Tasks of municipalities)

1. The municipalities:
b) do endow themselves, within three years from coming into force of the present law, with plans of lighting which will discipline all the new installations and plants in agreement with the present law, provided that the directives of letter d) and of art. 6, paragraph 1 will be respected;
c) do establish that all the installations of outdoor lighting, including those for advertising purposes, will be subjected to the authorization by the Mayor; thus the projects must be written up by one of the indicated professional figures for that field; the projects must be in agreement with the requirements of the present law and, at the end of the works, the setting up enterprises must issue a declaration of conformity of the lighting system, which has been realized according to articles 6 and 9, or, where indicated, a certificate of test in analogy with the directives of the law of March 5, 1990, n. 46 (Rules for the safety of plants and systems), for any existing installation

inside buildings; the described procedure is applied also to the installations for public lighting; the care and the burdens of the tests are charged to the buyer of the systems;
d) do provide, by periodic controls on their own initiative or upon request of astronomical observatories, or other scientific observatories, to guarantee the respect and the application of the present law by private and public subjects, on the territories of their own competence; do issue appropriate decrees, within sixty days from coming into force of the present law, for the best application of the principles for the control both of light pollution and of energy consumptions deriving from the outdoor lighting, with specific indications to the release of building licences;
e) do provide, also upon request of the astronomical observatories or other scientific observatories, to the verification of the points of light not corresponding to the requirements of the present law, ordering their modification or replacement or in any case their conformation to the established criteria, within one year from the notification of the recognized irregularity, and, expired said time, within sixty days without any further delay;
f) do impose, where indicated, the administrative endorsements according to following article 8, employing of the corresponding proceeds for the aims of the same article.

Article 5
(Directives in matter of astronomical observatories)

1. The National, astronomical, and astrophysical observatories, those professional and not professional ones of regional or provincial importance that carry out scientific research and/or popularisation of astronomy are protected by the present law.
2. The Regional Council, within 120 days from coming into force of the present law:
a) updates the directory of the observatories as defined in the following article 10, also on proposal of the Italian Astronomical Society and the Italian Amateur Astronomers Union;
b) issues an appropriate resolution to determine the corresponding respect zone.
3. The Regional Council, within 120 days from coming into force of the present law, characterizes by means of cartography in adequate scale the zones of protection, sending to the involved municipalities a copy of the cartographic documentation.
4. The astronomical observatories:
a) report to the competent territorial authorities the presence of sources of light not in conformity with the requirements of the present law, requesting the authorities intervention so that such lights will be modified or replaced or however conformed to the established criteria;
b) collaborate with the territorial agencies for a better and punctual application of the present law, according to their specific skills.

Article 6
(Regulation of sources of light and the use of electric energy for outdoor lighting)

1. To put into effect what provided for in Article 1, starting from the date of coming into force of the present law, all the installations of artificial outdoor lighting, public and private, either in phase of planning or contract must be executed according to anti-light-pollution rules and to reduced energy consumption criteria; for those already in phase of execution, it is mandatory to utilize systems not dispersing light up, if possible at once or followed by their successive adaptation, according to the criteria of the present article.
2.Only the systems, constituted by lighting apparatuses, having the maximum light intensity of 0 cd per 1000 lumen to 90° and beyond are considered as not light polluting and of reduced energy consumption; said apparatuses must be equipped with lamps having the highest possible efficiency in relation to the state of the technology; the same ones moreover must be realized in such a way that the illuminated surfaces do not exceed the minimal level of medium maintained luminance provided for the safety standards, and must be supplied with suitable control devices to reduce the

emission of light not less than thirty percent regarding the full regimen of operability, within 23.00 hours in the period of regular time and within 24.00 hours in the period of day-light saving time. Said emission reduction is applied when the conditions of use of the illuminated surface are such that the safety is not compromised; the directives regarding such control devices for the only reduction of the consumptions are optional for the structures belonging to activities for the public order, for the administration of the justice and the defence.
3. Exemptions are granted for not polluting internal sources of light, for those with emission not exceeding 1500 lumen each in systems of modest entity (up to three centres with one single point of light), for those of temporary use that are shut off within 20.00 hours in the period of regular time and within 22.00 hours in the period of day-light saving time.
4. The lighting of sign-boards not equipped with own lighting system must be realized by overhead lighting.
5. The use of reflectors, beacons and beacon-towers must be conformed, on the whole regional territory, according to what provided for in the following article 9.
6. The illumination of sport arenas and buildings and large areas of every type must be carried out employing criteria and means in order to avoid phenomena of light dispersion towards the sky and outside of the aforesaid surfaces.
7. The modification of the inclination of light sources, according to the criteria indicated in paragraph 2 of the present article, must be put into effect within eighteen months from coming into force of the present law.
8. The manufacturing, importing or supplier firms must certify the conformity to the present law of sources of light commercialised, among the technical characteristics, marking the product with the wording "anti-light-pollution and reduced energy consumption optic, according to the laws of the Lombardia Region", and enclose, moreover, the recommendations for a correct use.
9. It is expressly prohibited the use of rotating or fixed advertising beam-lights or beacons of whichever type, for the mere advertising purposes.
10. The illumination of buildings and monuments must be carried out by top-down lighting systems. Only if it is not technically possible and for subjects of particular and proven architectonic value, lighting must remain at least one meter under the upper edge of the surface to be illuminated and, in any case, within the perimeter of the same building or monument. The lighting systems must be supplied with suitable control devices to reduce the dispersion of the light (screens, fins) and to allow the total or partial shut off, or to reduce the power employed, within 23.00 hours in the period of regular time and within 24.00 hours in the period of day-light saving time.

Article 7
(Financial rules)
1. The authorization to expenses provided for in the present law will be granted with a subsequent provision of law.

Article 8
(Endorsements for protected zones)
1. Anyone, inside the zones of respect around the observatories protected by the present law, employs installations and sources of light not complying with the criteria indicated in articles 6 and 9 incur in the administrative endorsement from 200 Euros to 600 Euros, in case said lighting is not modified within sixty days from the notification by the Municipal Police of the competent municipality.
2. The administrative endorsement from 350 Euros to 1050 Euros is applied in case said lighting constitutes a remarkable source of light pollution, according to specific indications supplied by the competent astronomical observatories, and that are use at full power for all the duration of the night, even for simple advertising or voluptuary purposes.

3. The proceeds of said endorsements are employed by the municipality for the adaptation of the systems of public lighting according to the criteria provided for in the present law.
4. The public subjects, included the municipalities, omitting to conform to the criteria provided for in the present law within the periods of time indicated, are suspended from the benefit of reduction of the cost of the energy employed for the public lighting until they will adapt to said law and, within and not beyond four years, to the enforced norm.
5. The provision of previous paragraph 4 is adopted with deliberation of the Regional Council, after inspection and upon indication of the astronomical observatories territorially competent.

Article 9
(Directives for the protected zones)
1. Around every astronomical observatory and their sites, as indicated in the present article, it is instituted a zone of particular protection from light pollution, inside the regional boundaries, having a radius of:
a) 30 kilometres for the professional observatories;
b) 15 kilometres for the not professional observatories.

2. Within four years from coming into force of the present law, all sources of light not complying to indicated criteria and situated inside the zones of respect must be replaced and modified in such a way to reduce the light pollution and the energy consumption, by means of the high- and low-pressure sodium vapours lamps only.
3. The private subjects can proceed, in immediate way, to adapt the light systems as from paragraph 2, installing appropriate screens on the lamp bodies, or substituting the protecting glass of the lamps, as well as substituting the whole lamp, provided that said adaptation will be analogous to what provided for in the present article and article 6.
4. In order to reduce the energy consumption, all the interested subjects can proceed, in absence of adjusting devices of the light intensity, to shut off 50 percent of sources of light within 23.00 hours in the period of regular time and within 24.00 hours in the period of day-light saving time; the directives regarding such control devices for the only reduction of the consumptions are optional for the structures belonging to activities for the public order, for the administration of the justice and the defence.
5. All highly polluting lighting apparatuses already existing, like globes, lanterns and alike, must be shielded or in any case equipped with suitable screening device apt to limit and to direct the light flow to the ground, as well as equipped with transparent protecting glass. In any case the light intensity must not exceed 15 cd per 1000 lumen to 90° and beyond. Exemption are granted, according to specific indications agreed between the municipality and the competent astronomical observatories, to internal, not polluting, sources of light, for those with emission not exceeding 1500 lumen each (up to three centres with one single point of light), for those of temporary use that are shut off within 20.00 hours in the period of regular time and within 22.00 hours in the period of day-light saving time, for those which substitution is planned within four years from coming into force of the present law. The lighting of sign-boards not equipped with own lighting system must be realized from the top towards the bottom. In any case all the sign-boards of not specific and indispensable nocturnal use must be shut off within 22.00 hours in the period of regular time and within 24.00 hours in the period of day-light saving time.
6. The inclination, with respect to ground, of beacons, beacon- towers and reflectors use to light parkings, railway and streets, large squares, yards, industrial plants, sport arenas and areas of every type must be such as not to irradiate more than 0 cd per 1000 lumen to 90° and beyond. Floodlights of asymmetric type must be privileged in the selection.
7. The modification of the inclination of light sources, according to the indicated criteria, must be carried out within six months from coming into force of the present law.

Article 10
(Directory of the observatories)

1. The professional astronomical and astrophysical observatories to be protected are:

2. The not professional astronomical and astrophysical observatories of regional interest, having large cultural, scientific and popular importance to be protected are:

3. The not professional astronomical and astrophysical observatories of provincial importance which carry out any kind of scientific activity and/or popularization to be protected are:

Article 11
(Final instructions)

1. The Regional Council emanates the criteria of application of the present law within 180 days from coming into force of said law.
2. The municipalities outside the zones of respect defined in the article 9, paragraph 1, may integrally adopt the criteria provided for in the same article by means of appropriate decrees.

Article 12
(Coming into force)

The present law comes into force sixty days after its publication on the Official Bulletin of the Lombardy Region. The present regional law is published in the Official Bulletin of the Region.
It is compulsory to anyone to observe and to make to observe the present law, being it a law of the Lombardy Region.

Annex B

Lombardy Regional Council Decision no. 7/2611 of 11/12/2000

"Revision of the list of the astronomical observatories in Lombardy and determination of the relative respect zones"

Seen the regional law March 27th, 2000, no. 17 " Urgent measures to fight the light pollution and to achieve energy saving in the use of outdoor lighting" and in particular the art. 5 which assigns to the Regional Council the following fulfilments:

- the updating of list of the state astronomical- and astrophysical- observatories, professional and not, of regional or provincial importance, to be protected;
- the determination of the respect zones around said observatories;
- the identifying, by cartography in adequate scale, of the respect zones;

Recalled the list indicated in the art. 10 of said r.l. 17/00 which divides the observatories to be protected into three categories:

1. professional astronomical- and astrophysical- observatories;

2. not professional astronomical observatories of great cultural-, scientific- and popular importance, of regional interest;

3. not professional astronomical- and astrophysical observatories developing scientific- and/or divulgative activity, of provincial importance;

TAKEN NOTE of the verifications made by the competent Organizational Unity, as provided for the art. 5 of the r.l. 17/2000;

ACKNOWLEDGED that the identification of the protected zones for the three categories of observatories assumed as references the technical- and scientific experiences matured in the national and international field, highlighting that most tangible suppression of light emissions, about 70-80%, is obtained intervening on distances of the order of 25 km, beyond which the relief effects are much lower and showed that to achieve the almost total removal of light interferences it would be necessary to intervene on very extensive territorial ambits, especially in strongly urbanized zones such as those in Lombardy; (see Fig. 1 and its caption)

CONSIDERED, for the above motivations, to fix the following zones of protection, intended as radius around the considered observatory:

- not less than 25 km for the observatories of national importance, keeping in mind that the regional law 17/2000, even not imposing the total suppression of the lights in such areas, arranges a radical limitation of light emissions directed upwards;

- not less than 15 km for the observatories of regional importance, in order to achieve an average reduction of polluting light emissions of 55 - 60%;

- not less than 10 km for the observatories of provincial importance, in order to achieve an average reduction of polluting light emissions of 50%;

CONSIDERED also to include such areas of protection strips in the cartographies indicated in Annex C) of the present deliberation, of which it is integral and substantial part;

CONSIDERED, finally, to detail the previous determinations in the enclosures A), B) and D) which in the same way are integral and substantial parts of the present deliberation;

TAKEN NOTE that the Manager of the Organizational Unity competent in the field identifies the evaluations and determinations above stated, as first regulation of the art. 5 of the r.l. 17/00, reserving to re-examine said evaluations according to possible provisions, even technical, or directives or resolutions which should have to interest the specific subject;

EXAMINED AND ADOPTED the above-mentioned evaluations and determinations;

ACKNOWLEDGED that the present provision is not subject to control as provided for the art. 17 of the law no. 127 of May 15th, 1997;

DELIBERATES

1. to identify, for every observatories membership category, the areas of protection already indicated in the preamble and further specified as follows:

Professional astronomical- and astrophysical- observatories, : 25 km
[Observatory List 1]

Not professional astronomical observatories of great cultural-, scientific- and popular importance, of regional interest: 15 Km

[Observatory List 2]

Not professional astronomical- and astrophysical- observatories developing scientific- and/or divulgative activity, of provincial importance: 10 Km

[Observatory List 3]

2. to identify said areas of protection by cartographies annexed to the present deliberation, of which they constitute integral and substantial part;

3. to arrange that, within same areas, all the light sources not in conformity with the criteria indicated by the r.l. 17/2000 be replaced and modified in such a way to reduce the light pollution, as provided for the art. 9 of the r.l. 17/00;

4. to adopt the enclosures A), B) and D), better described in the preambles, as integral and substantial parts of the present deliberation;

5. to dispose that the cartographies indicated in the previous point 5) be transmitted to the Councils whose administrative territory be, all or in part, interested by the tie;

6. to remind the Districts of the fulfilments of which to the art. 3, letter b), of the r.l. 17/00, and to verify the light impact of the councils territories marginally interested by the tie, whose results must be sent to the Region for any possible further determinations;

7. to approve the annexes A, B, C and D, which constitute integral part of the present deliberation;

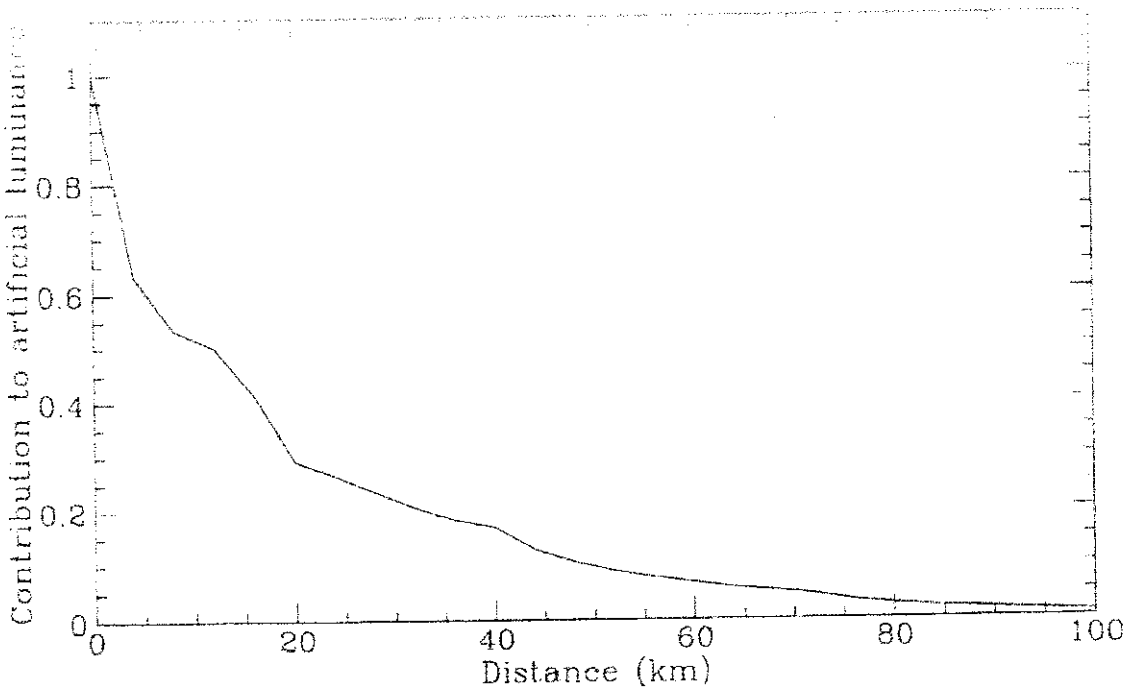


Fig. 1. The contribution to the total artificial sky brightness of the sources farer away from the observatory than the specified distance (0 to 100 km) in the case of San Benedetto Po Observatory. The sources farer than 25 km contributes about 25% to the total artificial sky brightness.

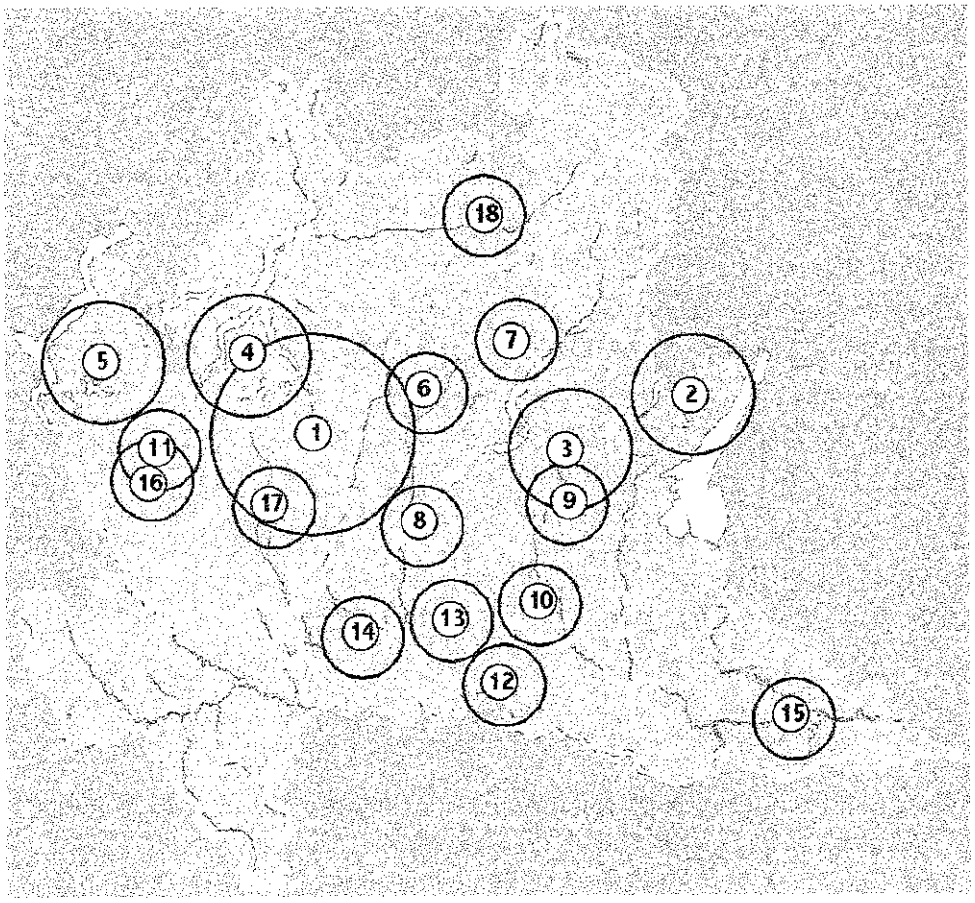
Annex C

List of the observatories, categories and reference geographic coordinates

Cartography used for the editing of the present deliberation annexes was realized with a dedicated software for geographic data management, using the rasterizzate maps as reference (cartography obtained through the scanning and the georeferenziazione of paper maps) and then vettorializzate (numerical cartography obtained through the georeferenziato drawing of the territorial objects) produced by the Lombardy Region.
The astronomical observatories were georeferenced on the Regional Technical Map (1:10.000 scale) and identified by a couple of coordinates, representing the latitude and the longitude of the observatory, expressed in meters in the system Gauss Boaga: x_coord and y_coord.
The protected zones were obtained creating buffer zones around every observatory, with different radii according to the category of the single structure.
The list of the municipalities interested by the protected zones was determined by the geographic intersection of the curves circumscribing the territories of the local government units and the protected zones themselves.

OBSERVATORY	**X_COORD**	**Y_COORD**
[Observatory List 1]		
[Observatory List 2]		
[Observatory List 3]		

[for example in Lombardy]

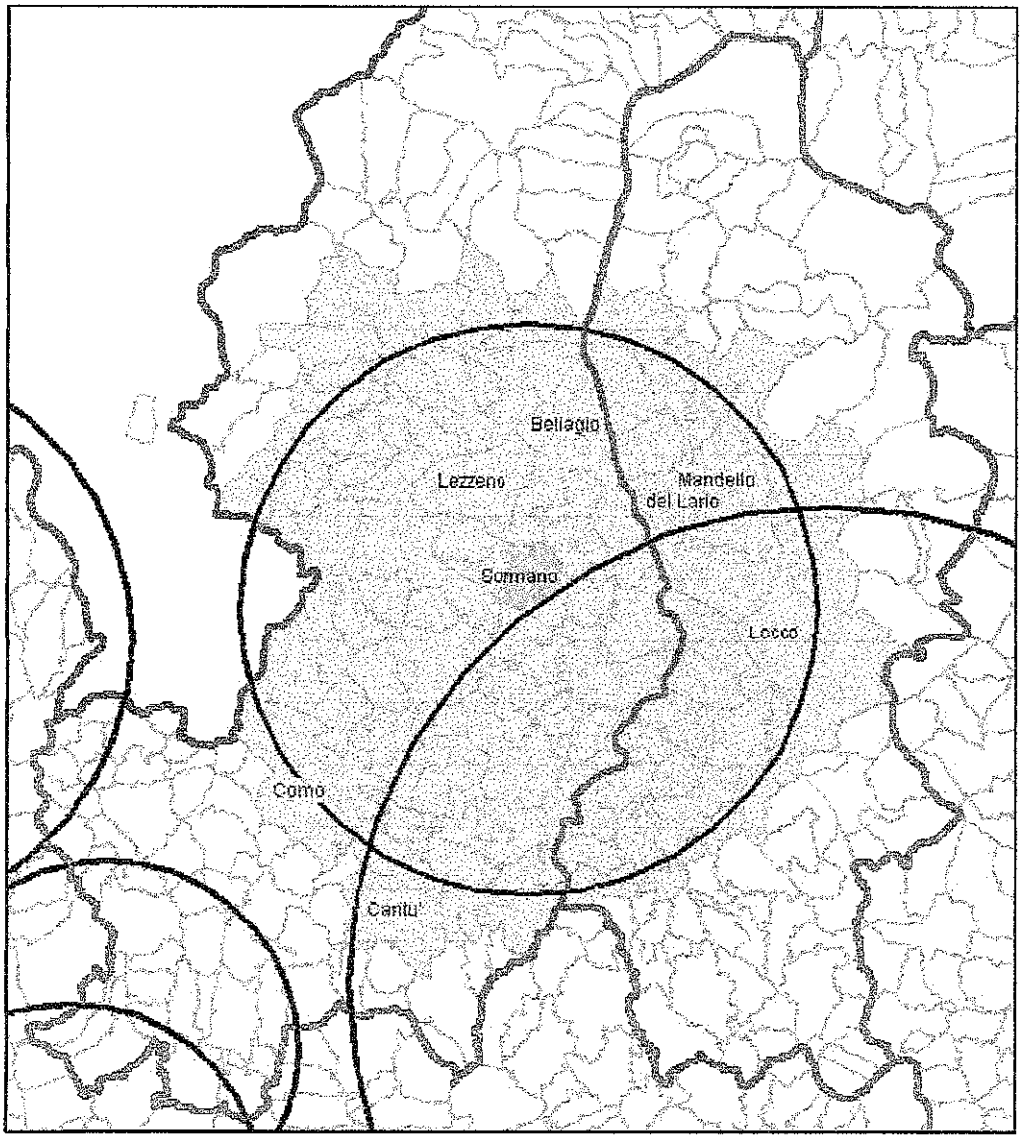


Annex D

Municipalities included into the protected zones

[For Example: Astronomical Observatory of Sormano (CO)]

Districts of Como
Sormano
[Municipality List]
.....
Districts of Lecco
Lecco
[Municipality List]
.....



Annex E

Model for a new good light pollution National Law (Similar to Lombardy Law)

ILLUSTRATIVE REPORT ON THE PROPOSAL OF REGIONAL LAW:
"URGENT MEASURES TO FIGHT THE LIGHT POLLUTION AND TO ACHIEVE ENERGY SAVING IN THE USE OF OUTDOOR LIGHTING"

1. PREMISE

Due to the excess of public and private lighting, it is more and more difficult to find places, in our regions, where the dark is such to allow an adequate vision of the celestial vault: on average only 10% of stars are by now visible on the territory, especially in the greater centres. We remain therefore deprived of the biggest natural show: the observation of the universe!

Uncontrolled wide-spreading of light pollution constitutes, as we will see, an unjustified energy waste, an alteration of the equilibrium of the ecosystem and an impediment, *de facto*, to the observation of the sky by the population. Some studies made clear the disturb to the fauna and to the flora due to the lack of day-and-night alternation in the zones too much illuminated; as an example the damage to migratory birds is intuitive, since they use stars in order to orientate in the nocturnal flight. In the recent Italian legislation, a precise reference is made to the necessity to prevent the light pollution: in the law on the protected natural areas - law of December 6, 1991, n. 394 -, where, in the article 11, the " light emissions" are indicated among the items that the park must discipline, in order to guarantee the pursuing of the conservation purposes and preservation of the natural patrimony. Also from a tourist point of view, the impact of highly illuminated areas is surely negative; to illustrate a real-life situation, the superb sceneries of ours Dolomiti mountains must be protected also from this kind of pollution.

At the Conference of Paris, in June 1992, the UNESCO evidenced the enormous damage brought to astronomy by an excessive artificial illumination and declared the starry sky "Patrimony of the mankind", to be protected for the future generations.

In our region numerous astronomical associations are active, and dedicate their energies, with passion and engagement, to the popularization of astronomy, both to the large public and in the schools (from the first classes to the University of the Third age), and play a role also in the official scientific research; these activities endure heavy limitations due to uncontrolled spreading of the light pollution; this cultural patrimony must be therefore effectively protected.

2. THE LIGHT POLLUTION: CAUSES AND REMEDIES

The light pollution is due to the dispersal in the sky of the brightness produced by the lights of towns and cities. The origin of the problem depends on the fact that often the planning of the lighting systems and the design of the points of light, does not keep into account the possible light dispersions outside the area to be illuminated. The absence of a legislation on this matter favours in fact the uncontrolled (and a sometimes counter-productive) floodlight, and a consequent waste of energy, by private and public agencies and single citizens. According to data supplied from the International Dark Sky Association (Tucson, Arizona USA), and confirmed also in Italy by recent studies of the Italian Astronomical Society (S.A.It.), more than 30% of the external illumination is dispersed towards the sky, leading to a huge squander of money, an irreparable damage to the astronomical research and culture and to the nocturnal image of the district. The importance of the astronomical research is demonstrated by the grants dedicated by all the industrial countries, Italy included. It has to pointed out that many lighting systems are now obsolete, since they are still based on incandescence or mercury vapours lamps, highly polluting on all the visible spectrum; these last ones must also be considered "special wastes", being highly toxic, with higher disposal costs. In local realm, the problem is even more aggravated by the installation of rotary advertising beacons useful, perhaps, to few privates but surely harmful for the entire collectivity forced to endure, without any advantage, a new type of landscape degradation. Moreover, such beacons deliberately violate the Art. 23 of the Italian New Code of the Road which prohibits, for safety reasons, their use and installation. **It is however important to point out that the problem of the light pollution is technically solvable, without compromising the possibility to have the roads**

illuminated in an adequate way. As an example, lamps habitually employed can be replaced, where possible, with high efficiency lamps like high-pressure sodium vapours lamps, less polluting and more efficient; the light dispersions could moreover be limited by use of full cut-off (totally shielded) systems or with asymmetric lamps equipped with appropriated shielding, directing the light with the right angle, from the high towards the bottom (avoiding therefore the floodlights inserted in the pavement). Equally important would be to adhere to the luminance values indicates in the directives and not to double or triple them without necessity. The suggestions are numerous and even the manufacturers of lighting systems offer, in their catalogues, some solutions provided that someone demands to them. **The today situation is placed in evident violation of the norms that impose suitable and opportune methods in order to contain the energetic consumption within acceptable limits,** dictated by the criterion of the real and consistent requirement (see the Italian Law n°10/1991 "Rules to actuate the National Energetic Plan for a rational use of energy, for energetic saving and development of the renewable sources of energy ").

The damage deriving from and uncontrolled use of electric energy in external lighting every year in Italy is at least 200 million Euros, (estimation made for year ' 96, with annual increases of approximately 10%); with due calculations it is possible to deduce the economic damage for our district. Studies carried out by S.A.It. have shown that in medium-sized cities (approximately 50,000 inhabitants), savings for approximately 100000 to 200000 Euros can be achieved, by means of a rational use of the energy in the public lighting only, diminishing at the same time the levels of light pollution and realizing also a fuel saving and consequently a lower emission of carbon dioxide (CO^2) into the atmosphere, the major responsible of "greenhouse effect". It can be calculated that the hypothetical discouragement of the light pollution on the whole Italian territory will lead to a saving of 430,000 tons of fuel in a year; consequently 1,350,000 tons of carbon dioxide would not be released, 1,480,000 tons of oxygen would not be burnt. From these considerations it is possible to confirm the importance and the urgency to approve a regional law that disciplines the lighting systems, both publics and private. It has to be observed, finally, that reducing the light pollution by the adoption of more modern planning criteria, means also to get cities better illuminated: in fact, avoiding that a part of light produced by the illumination systems goes dispersed towards the space, means to make it immediately available for a better visibility of the objects on the ground.

3. THE PROPOSED LAW: A SHORT COMMENT

The present law proposal is based on the one recently promulgated in Lombardy considered the best one among those approved up to now, according to those people who takes care the prevention of the light pollution. It is particularly effective in placing strict limits to the light dispersions. There are other regions that have been equipped with a law on lighting, e. g. Veneto, Tuscany, Lazio; in others the norm is still in phase of proposal. We introduce few improvements and additions based mainly on the later regional application criteria .

Any modification, suggestion or adjustment of the present text has been done in agreement with the Coordination of the Astronomical Associations of Lombardy and CieloBuio; the law proposal is constituted from 12 articles.

Main aims are:

art.1 - the control of the energy consumptions deriving from the use of outdoor lighting systems, either public and private, the adequate choice of light sources and the protection of the night sky for the public, the reduction of light pollution on the provincial territory.

art.2 introduces the national laws which inspired the present law and the tasks the Region must assume in order to observe and to make the law observed.

art.3 characterize the delegations to the Regional Administration: address, promotion, advising and coordination, as well as dissemination of the general principles of the law and control on its application in the regional territory. The Region is also called to divulgate the knowledge of the principles of the law as well as, if there exists a protected Observatory in their territory, to compile the directory of the Municipalities which must conform to said law in due time.

art.4- the municipalities must adopt a plan for the lighting, in agreement to the present law, and guarantee its application and observation; they issue decrees in order to uniform the sources of light

and apply the administrative endorsements, according to **art.8**, to not complying people and entreprises.

art.5 supplies directives about the protection of astronomical observatories of regional and provincial importance, which are called to monitor the zones of respect, pointing out illegitimate light sources.

art.6 provides specific standards, to be applied on the whole regional territory, to which constructors, importers and suppliers of lighting system and material will have to conform. New directives to correctly lighting monuments, railway and streets, parkings and sport arenas, are given.

art. 9 gives provisions to be adopted in the adjustment of existing installations.

art.10 lists to the observatories and the sites to be protected. Such directory will regularly updated according the previous **art.5**.

"URGENT MEASURES TO FIGHT THE LIGHT POLLUTION AND TO ACHIEVE ENERGY SAVING IN THE USE OF OUTDOOR LIGHTING"

Article 1
(Purpose)

1. The present law, according to what established in the article 3, paragraph 3, points 7, 8, 9 of the Statute of the Region, has for deriving purposes the reduction on the regional territory of the light pollution and the energy consumptions deriving from it, and consequently the protection of the activities of scientific research and popularisation carried out by the professional astronomical observatories of regional or provincial importance or other scientific observatories, the conservation of the ecological equilibriums either inside or outside the preserved natural areas as well as the protection of the night sky for all the population.
2. (To the aims of the present law) it is considered as light pollution of the atmosphere every artificial light irradiation that is dispersed outside the areas to which it is functionally dedicated and, specifically, if oriented above the plane of the horizon.

Article 2
(Tasks of the Region)

1. In order to actuate the National Energetic Plan the Regional Council stimulates the adaptation of the existing installations of outdoor lighting also in relation to the laws of January 9, 1991, n. 9 ("Rules to actuate the National Energetic Plan: institutional aspects, hydro-electric power plants and electric pipelines, hydrocarbons and geothermic, self-production and fiscal provisions") and of January 9, 1991, n. 10 ("Rules to actuate the National Energetic Plan for a rational use of energy, for energetic saving and development of the renewable sources of energy ").
2. All contracts and their specifications relevant to the public and private lighting must be consistent with the aims of the present law.

Article 3
(Tasks of the Districts)

1. The Districts (provinces):
   c) do exert the control on the correct and rational use of the electric energy for outdoor lighting and provide to divulge the principles dictated in the present law;
   d) can introduce, even on proposal of the Astronomical observatories or other night sky protection agencies, after consulting the interested municipalities, further protection requirements on the external lighting;
   e) within a year identify, even on proposal of the Astronomical observatories or other night sky protection agencies, the existing main sources of light pollution to correct in the first place;
   f) do exert the control on their jurisdiction lighting.

Article 4
(Tasks of municipalities)

1. The municipalities:
g) do endow themselves, within three years from coming into force of the present law, with plans of lighting which will discipline all the new installations and plants in agreement with the present law, provided that the directives of letter d) and of art. 6, paragraph 1 will be respected;
h) do establish that all the installations of outdoor lighting, including those for advertising purposes, will be subjected to the authorization by the Mayor; thus the projects must be written up by one of the indicated professional figures for that field; the projects must be in agreement with the requirements of the present law and, at the end of the works, the setting up enterprises must issue a declaration of conformity of the lighting system, which has been realized according to articles 6 and 9, or, where indicated, a certificate of test in analogy with the directives of the law of March 5, 1990, n. 46 (Rules for the safety of plants and systems), for any existing installation inside buildings; the described procedure is applied also to the

installations for public lighting; the care and the burdens of the tests are charged to the buyer of the systems;

i) do provide, by periodic controls on their own initiative or upon request of astronomical observatories, or other scientific observatories, to guarantee the respect and the application of the present law by private and public subjects, on the territories of their own competence; do issue appropriate decrees, within sixty days from coming into force of the present law, for the best application of the principles for the control both of light pollution and of energy consumptions deriving from the outdoor lighting, with specific indications to the release of building licences;
j) do provide, also upon request of the astronomical observatories or other scientific observatories or night sky protection associations, to the verification of the points of light not corresponding to the requirements of the present law, ordering their modification or replacement or in any case their conformation to the established criteria, within one year from the notification of the recognized irregularity, and, expired said time, within sixty days without any further delay;
k) do impose, where indicated, the administrative endorsements according to following article 8, employing of the corresponding proceeds for the aims of the same article.

Article 5
(Directives in matter of astronomical observatories)

The astronomical observatories:

c) help the competent administrative authority in identifying and conforming the existing main light pollution sources;
d) help the competent administrative authority in divulge the aims and means of the present law;
e) report to the competent territorial authorities the presence of sources of light not in conformity with the requirements of the present law, requesting the authorities intervention so that such lights will be modified or replaced or however conformed to the established criteria;
f) collaborate with the territorial agencies for a better and punctual application of the present law, according to their specific skills.

Article 6
(Regulation of sources of light and the use of electric energy for outdoor lighting)

1. To put into effect what provided for in Article 1, starting from the date of coming into force of the present law, all the installations of artificial outdoor lighting, public and private, either in phase of planning or contract must be executed according to anti-light-pollution rules and to reduced energy consumption criteria; for those already in phase of execution, it is mandatory to utilize systems not dispersing light up, if possible at once or followed by their successive adaptation within four years, according to the criteria of the present article.
2. are considered as not light polluting and of reduced energy consumption only the systems, constituted by lighting fixtures, that have simultaneously all these characteristics:

a) maximum light intensity of no more than 0 cd per 1000 lumen to 90° and beyond;
b) be equipped with lamps having the highest possible efficiency in relation to the state of the technology; only if the chromatic rendition is mandatory (for Color television sport events broadcast) the use of broad emission lamps such as Metal halide is allowed;
c) must be realized in such a way that the illuminated surfaces do not exceed the minimal level of medium maintained luminance provided for the safety standards, or in absence of safety rules, do not exceed 1 cd/m^2 ;
d) must be supplied with suitable control devices to reduce the emission of light not less than thirty percent regarding the full regimen of operability, within 23.00 hours in the period of regular time and within 24.00 hours in the period of day-light saving time. Said emission reduction is applied when the conditions of use of the illuminated surface are such that the safety is not compromised; the directives regarding such control devices for the only

reduction of the consumptions are optional for the structures belonging to activities for the public order, for the administration of the justice and the defence.

3. Exemptions are granted for:
   - not polluting internal sources of light;
   - those of temporary installation that are shut off within 20.00 hours in the period of regular time and within 22.00 hours in the period of day-light saving time;
   - installations with emission not exceeding a total of 2250 lumen above the horizon in systems of modest entity (i.e. equipped with lamps of no more than 1500 lumen each);

4. The lighting of sign-boards not equipped with own lighting system must be realized by overhead lighting allowing no light escaping above the plane of the horizon. The internal lighted sign must not exceed 3000 lumen of total flux in every direction for each property. All sign must be shut off within 20.00 hours in the period of regular time and within 22.00 hours in the period of day-light saving time or no later than the closing time of the shop.

5. The inclination, with respect to ground, of beacons, beacon- towers and reflectors use to light parkings, railway and streets, large squares, yards, industrial plants, sport arenas and areas of every type must be such as not to irradiate more than 0 cd per 1000 lumen to 90° and beyond. Floodlights of asymmetric type must be privileged in the selection

6. The illumination of sport arenas and buildings and large areas of every type must be carried out employing the criteria in the preceeding comma 1 and 2 and avoid also phenomena of light dispersion outside of the aforesaid surfaces. It must be also possible the reduction of the illumination levels in accordance with the type of activities (international sport event with TV coverage, local event, training event etc.)

7. The manufacturing, importing or supplier firms must certify the conformity to the present law of sources of light commercialised, among the technical characteristics, marking the product with the wording "anti-light-pollution and reduced energy consumption optic, according to the laws of the Lombardia Region", and enclose, moreover, the recommendations for a correct installation and use.

8. It is expressly prohibited in all regional territory the use of rotating or fixed advertising beam-lights or beacons of whichever type, colour and power or the use of other lighting or lighted structures like aerostats, kites, satellites for the mere advertising purposes.

9. The illumination of buildings and monuments must be carried out by top-down lighting systems in accordance to paragraph 2 of this article. Only if it is not technically possible and for subjects of particular and proven architectonic and historic value, other type of lighting are allowed. In any case lighting must remain at least one meter under the upper edge of the surface to be illuminated and, within the perimeter of the same building or monument. The lighting systems must be supplied with suitable control devices to reduce the dispersion of the light (screens, fins) and to allow the total or partial shut off, or to reduce the power employed, within 23.00 hours in the period of regular time and within 24.00 hours in the period of day-light saving time. The maximum allowed luminance is 1 cd/m^2.

10. For all existing fixtures not in accordance with this law, where allowed by the security rules, it is mandatory to modify the inclination of light sources, in order to respect the criteria indicated in paragraph 2 of the present article, within eighteen months from coming into force of the present law.

11. To favour high efficiency installations it is necessary:
   - to take into account the colour and reflectivity of the lighted surfaces in calculating the luminance;
   - to use, luminance being equal, the lowest electric power and the highest distances between fixtures;
   - to maintain a luminance lower than 1 cd/m^2 on the lighted surfaces, except when a security standard rule ask for higher values. In this last case, use the lowest value of the norm.

12. In each municipality the lumens of new fixtures installed each year must not exceed the 2% of the total municipality lumens in public external lighting.

Article 7
(Financial rules)

1. The authorization to expenses provided for in the present law will be granted with a subsequent provision of law.

Article 8
(Endorsements and fines)

1. Installations built in violation of the present law must be maintained shut off until the adjustment. The switching on is subject to a fine of 200 to 600 Euros for each night and for each fixture.
2. Anyone employing installations and sources of light not complying with the criteria indicated in articles 3, 6 and 9 incur in the administrative endorsement from 200 Euros to 600 Euros for each fixture, in case said lighting is not modified within sixty days from the notification by the Municipal Police of the competent municipality.
3. The administrative endorsement from 350 Euros to 1050 Euros is applied in case said lighting constitutes a remarkable source of light pollution, according to specific indications supplied by the competent astronomical observatories, and that are use at full power for all the duration of the night, even for simple advertising or voluptuary purposes.
4. The proceeds of said endorsements are employed by the municipality for the adaptation of the systems of public lighting according to the criteria provided for in the present law.
5. The public subjects, included the municipalities, omitting to conform to the criteria provided for in the present law within the periods of time indicated, are suspended from the benefit of reduction of the cost of the energy employed for the public lighting until they will adapt to said law and, within and not beyond four years, to the enforced norm.
6. The provision of previous paragraph 4 is adopted with deliberation of the Regional Council, after inspection and upon indication of the astronomical observatories territorially competent.

Article 9
(Directives for the adjustment of existing installations)

1. The adjustment of existing installations must follow these directives:

a) Within four years from coming into force of the present law, all sources of light with power equal or exceeding 400 W in fixtures not complying to indicated criteria must be modified or replaced in accordance to the present law;
b) Within eight years from coming into force of the present law, all sources of light with power lower than 400 W but equal or exceeding 150 W in fixtures not complying to indicated criteria must be modified or replaced in accordance to the present law;
c) Within twelve years from coming into force of the present law, all sources of light with power lower than 150 W in fixtures not complying to indicated criteria must be modified or replaced in accordance to the present law;

2. For the existing main sources of light pollution see article 3. The ajustment must be carried out in accordance to article 6
3. The private subjects can proceed, in immediate way, to adapt the light systems as from paragraph 2, installing appropriate screens on the lamp bodies, or substituting the protecting glass of the lamps, as well as substituting the whole lamp, provided that said adaptation will be analogous to what provided for in the present article and article 6.
4. In order to reduce the energy consumption, all the interested subjects can proceed, in absence of adjusting devices of the light intensity, to shut off 50 percent of sources of light within 23.00 hours in the period of regular time and within 24.00 hours in the period of day-light saving time; the directives regarding such control devices for the only reduction of the consumptions are optional for the structures belonging to activities for the public order, for the administration of the justice and the defence.

Article 10
(Directory of the observatories)

00453

1. The professional astronomical and astrophysical observatories to be protected are:
2. The not professional astronomical and astrophysical observatories of regional interest, having large cultural, scientific and popular importance to be protected are:
3. The not professional astronomical and astrophysical observatories of provincial importance which carry out any kind of scientific activity and/or popularization to be protected are:

Article 11
(Final instructions)

1. The Regional Council emanates the criteria of application of the present law within 180 days from coming into force of said law.
2. The municipalities outside the zones of respect defined in the article 9, paragraph 1, may integrally adopt the criteria provided for in the same article by means of appropriate decrees.

Article 12
(Coming into force)

The present law comes into force sixty days after its publication on the Official Bulletin of the Region. The present regional law is published in the Official Bulletin of the Region.
It is compulsory to anyone to observe and to make to observe the present law, being it a law of the Region.

Annex F
Lighting plans: an introduction

1 - INTRODUCTION TO THE REGIONAL PROVISIONS FOR ENERGY SAVING AND AGAINST LIGHT POLLUTION

The recent introduction of regional laws regulating the public and private outdoor lighting pushes the councils to provide themselves with plans of lighting which define some homogeneous criteria of territory lighting.
In particular the Lombardy Regional Law no. 17 of 03.27.2000 *"Urgent measures to fight the light pollution and to achieve energy saving in the use of outdoor lighting"* (BURL of 03/30/00, suppl. No. 13) (Annex 1), specifies in art. 4, comma 1, letter a): "[The municipalities] do endow themselves, within three years from coming into force of the present law, with plans of lighting which will discipline all the new installations and plants in agreement with the present law, provided that the directives of letter d) and of art. 6, paragraph 1 will be respected".
The situation at the coming into effect of the above-mentioned law is quite articulate and confused, as not existing a real national provisions in matter of lighting, the interventions performed on the territory have been realized without any programmatic intent, with the only purpose to provide for the contingent demands that from time to time arise on the territory.
Moreover, most of the times the installations have been realized without considering the pre-existing situations, confusedly overlapping and in a not homogeneous way installations having aims and intents independent and totally different.
The realization of a lighting plan has the function to shot a picture of the territorial situation and to organize and optimize in an organic way the public and private lighting, in full observance of the above mentioned laws. Therefore the lighting plan is the main tool to make such laws effective and operating.

The operating ambits of public lighting plans (P.L.P.) are the following:
- from a technical point of view they plan the lighting of the territory, the interventions of updating of the plants and their maintenance;
- from an economic point of view they allow to plan in advance the interventions and to manage the costs in a rational way, leading to a considerable energy saving.

2 What is a Public Lighting Plan

A Public Lighting Plan consists in a project and a complex of technical dispositions aimed to regulate the installations of public and private outdoor lighting. Such a plan, will be realized according to the specifications and in full observance of the Lombardy Regional law no. 17 of 03.27.2000 and the possible current regional or national provisions (Decree "New Code of the Road" of April 30th, 1992 n.285, rules for the putting into effect of the laws no. 9 and 10 of January 1991 on the new National Energy Plan, or technical European and National norms, such as CEI, DIN and UNI).
The dispositions coming from such a plan have application on the whole municipal territory for installations of future realization, while if such territories are comprised in areas of tutelage of the regional astronomical observatories (according to the lists drafted by the regional council), the lighting plans must already arrange also for the planned replacement and for the adjustment of the existing installations.
Another necessity of these plans is also to tutelate the territory and his image either during day and the night, supporting choices which increase its value.
The adoption of lighting plans, does not involve the burdens, the completeness and the complexity of the Municipal Regulating Plans of lighting and however they do not constitute a limitation, but a guide, if necessary, for those councils which must necessarily provide them similarly to the Urban Plans Of The Traffic (Art.36 paragraph 1 and 2 of the Decree on

the New Code of the Road, April 30th, 1992 n.285, D.M. 04/12/95 Ordinary Suppl. n.77 to the Official Gazette n.146 of 06/24/95).

2.1 Requirements and motivations

1. reduction of light pollution;
2. energy saving and economic planning;
3. safeguard and protection of the environment;
4. safety of the traffic, of the people and the territory;
5. increase in value of the urban environment, some old cities centres and residential;
6. improvement of the road network.

2.2 Beneficiaries of the lighting plans

- the citizens;
- the recreational and commercial activities;
- the councils who directly manage thei own lighting installations;
- the managing boards of public and private lighting installations;
- the illuminotechnical designers;
- the lighting equipment manufacturers and the installer enterprises;
- the organizations which audit the safety of electric and lighting plants;
- the Department of Employment and of Social Security and the insurance companies, for the reduction of the number of the accidents;
- the law and order, for the reduction of the micro-crime and of the vandalism acts;
- the environment, safeguarding of the local flora and fauna;
- the professional- and amateur-astronomers, for the reduction of the light pollution.

2.3 Economic benefits

Since the new law provisions foresees interventions which will prolong in the time and will modify the typology of the new installations and lighting plants, the economic benefits which will derive will be remarkable as combination of a few determinant factors: reduction of the dispersion of the invasive light flow in areas where it was not devised for, control of public and private lighting avoiding useless and undesired waste, reduction of the light flows on roads during the night and finally, use of installations equipped with the highest efficiency lamps, in relation to the state of the technology.
To increase the economic advantages, besides the action led on the lighting equipment, it is necessary to plan a rationalization and standardization of the service plants (electric lines, poles and supports, etc.) and the use of high technology plants with low costs of management and maintenance.

2.4 Normative references and bibliography

Laws:

- Law of the Lombardy Region no. 17 of 03/27/2000 "Urgent measures to fight the light pollution and to achieve energy saving in the use of outdoor lighting " and related Accomplishment Regulations,
- Regional Council Decision no. 7/2611 of 11/12/2000"Revision of the list of the astronomical observatories in Lombardy and determination of the relative respect zones"
- Government decree no. 285 of 4.30.1992: "New Code of the Road"
- DPR 495/92: "Execution and Accomplishment Regulations for the"New Code of the Road"

- Decreto legislativo 360/93 : "Disposizioni correttive ed integrative del Codice della Strada" approvato con Decreto legislativo n. 285 del 30-4-1992
- D.M. 12/04/95 Supp. ordinario n.77 alla G.U. n.146 del 24/06/95 "Direttive per la redazione, adozione ed attuazione dei piani Urbani del traffico".
- DPR 503/96 : "Norme sulla eliminazione delle barriere architettoniche"
- leggi n. 9 del gennaio 1991 "Norme per l'attuazione del nuovo Piano energetico nazionale: aspetti istituzionali, centrali idroelettriche ed elettrodotti, idrocarburi e geotermia, autoproduzione e disposizioni fiscali"
- Legge n. 10 del 9 gennaio 1991 "Norme per l'attuazione del Piano energetico nazionale in materia di uso razionale dell'energia, di risparmio energetico e di sviluppo delle fonti rinnovabili di energia"
- Allegato II Direttiva 83/189/CEE legge del 21 Giugno 1986 n.317 sulla realizzazione di impianti a regola d'arte e analogo DPR 447/91 (regolamento della legge 46/90)\

Technical Norm:

- Norma DIN 5044 o l'analoga, ma attualmente meno completa, Norma UNI 10439 : "Requisiti illuminotecnici delle strade con traffico motorizzato"
- Norma CEI 34 – 33 : "Apparecchi di Illuminazione. Parte II : Prescrizioni particolari. Apparecchi per l'illuminazione stradale"
- Norme CEI 34 relative a lampade, apparecchiature di alimentazione ed apparecchi d'illuminazione in generale
- Norma CEI 11 – 4 : "Esecuzione delle linee elettriche esterne"
- Norma CEI 11 – 17 "Impianti di produzione, trasmissione e distribuzione di energia elettrica. Linee in cavo"
- Norma CEI 64 – 7 : "Impianti elettrici di illuminazione pubblica e similari"
- Norma CEI 64 – 8 relativa alla "esecuzione degli impianti elettrici a tensione nominale non superiore a 1000 V"

Bibliography:

- CIE Pubblicazione n. 92 : "Guide to the lighting of urban areas" (1992)
- CIE Pubblicazione n. 115 : "Recommendations for the lighting of roads for motor and pedestrian traffic" (1995)
- ENEL/Federelettrica "Guida per l'esecuzione degli impianti di illuminazione pubblica" (1990)
- AIDI "Raccomandazioni per l'illuminazione pubblica" (1993)
- Piano Urbano Traffico (PUT)
- "Guida per il Piano Regolatore Comunale dell'Illuminazione Pubblica", AIDI Gennaio 98
- "Manuale di Illuminotecnica", Francesco Bianchi, NIS Febbraio 95
- "Impianti a norme CEI – volume 6: Illuminazione Esterna", TNE Maggio 97
- "Piani Comunali di illuminazione Urbana", Ing. Germano Bonanni, Rivista Luce n.6/94
- "Il piano comunale per l'illuminazione pubblica. Scelta e strategie per la pianificazione degli impianti", Arch. Giovanni Burzio, Rivista Luce n.5/95
- "Illuminazione pubblica e sicurezza", Fernando Prono, Rivista Luce Aprile 98
- "Inquinamento luminoso e protezione del cielo notturno" dell'Istituto Veneto di Scienze, Lettere ed Arti - Dott. Pierantonio Cinzano, dell'Università di Padova.
- "Inquinamento luminoso un problema per tutti ", CieloBuio – Coordinamento per la protezione del cielo notturno UAI & IDA, Marzo 2000.

3 - Municipal Plan for Outdoor Public Lighting : Aim

3.1 Definition of Light Pollution

Every artificial light irradiation that is dispersed outside the areas to which it is functionally dedicated and, in particular way, if oriented above the line of the horizon is considered as light pollution (R.L. no.17 of 03/27/00 - Annex 1).

3.2 Aims of the lighting plans

a) Reduce, on the whole territory, the light pollution and the energy consumptions from it deriving,
b) Increase the road safety for the reduction of the accidents, avoiding dazzlings and carelessnesses that can create dangers for the traffic and the pedestrians (according to the "Code of the Road"),
c) Reduce the crime and the vandalism which tend to increase where the illumination is not homogeneous, creating half-light zones very close to highly illuminated areas (as from researches led in United States),
d) Foster the evening recreational and commercial activities to improve the quality of life,
e) Increase a more rational exploitation of the available urban spaces,
f) Improve the lighting of the architectural works and their beauty, with the opportune chromatic choice (i.e. the golden yellow of high-pressure sodium lamps is especially suitable in the old cities centres), of the intensities and the type of lighting, avoiding useless and damaging dispersions of the light in the surrounding areas and towards the sky without creating sickening contrasts with the surrounding environment (i.e. by a too much intense lighting),
g) Combine the lighting installations with the environment which surrounds them, both diurnal and nocturnal,
h) Realize high efficiency installations, by the use of full cut-off devices, of high yield lamps and by the control of the light flow, supporting the energy saving,
i) Optimize the management burdens and those concerning the maintenance interventions,
j) Protect, in the areas of protection of astronomical observatories , the scientific research activities and divulgation,
k) Preserve the ecological balances both inside and outside the urban and rural protected natural areas,
l) Preserve the possibility for the population to enjoy the starry sky, as a primary cultural asset.

3.3 Identification of study phases and plan development

Subdivision of the territory and identification of homogeneous areas

1. environmental
2. historical
3. town planning

Verification of lighting devices and their distribution on the territory

- number and typology of the light points;
- typology of the supports and their environmental impact;
- characteristics of energy distribution plants and of the electric lines supplying the lighting devices;
- Assessment of the more significant illuminotechnical parameters: illumination, uniformity, dazzling and chromatic yield.

Elaboration of a project of integration and intervention on the territory
On the basis of what emerged from the subdivision into homogeneous areas, and from the real distribution, a specific plan is elaborated dividing the municipal territory according to precise choices of lighting, in such a way that the planning of the interventions of maintenance and of environmental rearrangement will occur according to prescribed technical choices.

Identifcation of the opportunities
Technical-economic evaluation of the gains deriving from the execution of maintenance and recovery interventions planned.

4 - Public Lighting Plan: Working ambits

4.1 Assessment of the existing installations

The survey methodology must identify the following essential characteristics of the installations:
- Owners and administrators (ENEL, municipalities, local government boards or private ones, others),
- Voltage, electric powers applied and type of electric distribution,
- Typologies of the installed devices (floodlights, street lamps, spheres, etc.) and of the supports used (single and multiples poles, beacon-towers, suspension, shelf or wall support, etc.),
- Distribution of the lamps installed in the plants divided by type (fluorescence, high- or low-pressure sodium lamps, metal halogenides, Mercury, etc) and by power (50 W, 100 W, etc.),
- Presence of: annoying dazzlings, invasive lighting, evident light pollutions, lack of homogeny, insufficiency or excess of lighting.

4.2 Subdivision of the territory

The subdivision of the municipal territory, and the technical choices to be adopted, must consider the following situations:

- distribution and morphology of the ground (plain, hill, mountain),
- subdivision in homogeneous areas: in districts, old cities centres, industrial zones, parks, residential areas, highways, ring roads, motorways, countryside, etc.
- prevailing climatic aspects which can affect the road network and the visibility, i.e. if the territory is particularly rainy, humid, snowy or supports air stagnation with the probable formation of fogs,
- environmental aspects such as the presence of artificial or natural elements able to attack lighting installations like, for instance, the sea (with the saltness abundance), or big industrial complexes (with emissions of polluting or corrosive substances), etc.
- the inclusion into areas of protection of astronomical observatories and other scientific observatories, which involves a particular consideration in the design of the plants for the safeguard of the night sky.

4.3 Homogeneous areas

In particular, homogeneous areas can be divided by the typologies of identified roads, by urban plans of the traffic (if any), by the Code of the Road and by the European technical provisions, or on the basis of pure wits criteria:
- Old cities centres,
- Pedestrian areas,

- Shopping areas and centres,
- Residential areas,
- Green areas,
- Industrial and artisanal areas,
- Extra-urban areas,
- Limited areas of particular purpose, identifying: their distribution on the territory, their integration inside the homogeneous areas, their destination (archaeological, sporting plants, shopping centres, etc.) and all the informations to univocally distinguish and identify them.

The choice of the lighting must above all take into consideration the technical indications of the Lombardy Regional Law n.17 of 03.27.00.

4.4 Drawing up the lighting plan

Analysis of the current situation

a) Identification of the existing road network (urban, rural, pedestrian, etc.)..)
b) subdivision and classification of the roads on the basis of the "New Code of the Road" and according to the indications of the European technical provisions (Annex 2).

Technical and illuminotechnical options

a) Identifying of the illuminotechnical characteristic parameters (luminance and illumination, uniformity, dazzling) on the basis of the roads classification (Annex 2).
b) Choice of the characteristics of the lamps to be adopted in each urban and extra-urban context (Annex 2).

Technical-installing choices: For new plants or the adjustment of the old ones

a) Level of protection (IP) and isolation Class (I or II),
b) Geometry and typology of the plants (poles, suspensions, shelfs, wall supports, beacon towers, etc.),
c) Choices for the electric protection of the plants, planning possible abundant full circuits for the safety of the plants, and reduce the risks of sudden black-outs of the network,
d) Laying of the electric lines (aerial, underground) ,
e) Improvement of the illuminotechnical total yield (useful flow - installed power ratio),
f) Inclusion in-line of regulators for the control of the emitted light flow and its variation according to specific calibration curves,
g) Arrange for diagnostic electronic systems to reduce the maintenance of the plants and improve the services.

Planning choices

a) Planning and operating choices by homogeneous areas (Annex 2),
b) Planning choices for particular applications (Annex 2):
    - Monuments,
    - Large areas,
    - Outdoor Sport Arenas and buildings
c) Optimization:
    - of the light signposting according to visibility and priority criteria,
    - of shopping precinct lighting respecting the safeguard of the town environment, limiting the power, the extent and the diffusion,

    Adoption of anti-light pollution criteria (Annex 1).
d) Arrange for illuminotechnical special priority choices in correspondence of risky areas (generally very limited) which require higher attentions as:
    - Sporting centres (football fields, racecourses, swimming pools, gymnasiums, etc.),
    - School areas (close to the entrances),

- Shopping centres (in correspondence of areas intense pedestrian traffic),
- Exchange areas, like the accesses to railway stations,
- Important link roads having intense urban and extra-urban traffic.

Planning

- Definition of plans of maintenance and adjustment of the installations,
- Economic estimate of the costs of maintenance, adjustment and management. Expense forecasts in relation to the real liquid assets and to the priorities on the territory.

Documentation

If the Council already has an Urban Plan of Traffic (UPT), the lighting plans are included in the most complete version of Regulating Plans Of The Lighting, directly subordinated to the UPT for the classification and complementary for the purposes.

In general, the documentation constituting the body of a standard regulating plan can be synthetized as follows:

Graphics and designs

- Planimetries of the municipal territory divided by homogeneous areas (compatible with the possible GRP),
- Planimetries of already existing installations, with the identifcation of main technical and functional characteristics,
- Planimetry of areas classification and related functional typologies,

Reports

- Introductory report on the distribution of the municipal territory
- Report on the historic-environmental characteristics
- Descriptive report on special destination areas, on critical zones and buildings, and on their environment,
- Report on the definition and localisation of any new installation planned on the territory according to the specifications for the homogeneous areas and typology of installation,
- Economic and programmatic report for the evaluation of costs of realization, maintenance, and management of the installations, including the definition of the interventions in relation to the municipal liquid assets.

In case the UPT is not required, and the Council is of small dimensions, such tools can be greatly simpler in terms of objectives, purposes and documentation.

Annex G

NEW INSTALLATIONS ON THE WHOLE REGIONAL TERRITORY

INDICATIVE TABLE FOR THE ADJUSTMENTS OF OUTDOOR LIGHTING INSTALLATIONS ACCORDING TO R.L. N.17/00 OF THE LOMBARDIA REGION AND RELATED REGULATION

VIOLATION ASSESSMENT FORM N. _____

Locality/Street _____

Town _____

VERIFIED VIOLATION		RECOMMENDED ADJUSTMENT
Lighting devices – Maximum Light Intensity Allowed 0cd/klm at 90° and beyond (art.6, commas 2 & 5)		
☐ Not full cut-off with protruding lamp and/or not transparent glass (spheres, lanterns, street lamps, road armours, projectors)	⟹	Replacement option: ☐ with full cut-off optics and lamp recessed in the upper part of the device ☐ if possible, replace the cup with horizontal flat glass
☐ full cut-off Devices with wrong inclination and light dispersion	⟹	☐ Modify the inclination ☐ Insert a shield in the upper part
Lamps - High efficiency (art.6, comma 2)		
☐ Low efficiency lamp such as mercury-vapours lamps or fluorescence lamps	⟹	Replace with high efficiency lamps >100 lm/W such as high- or low-pressure sodium lamps
Illuminated surfaces (art.6, comma 2)		
☐ Minimum level of mantained average luminance higher than that indicated by the safety rules	⟹	Reduce the installed power
Signboards without their own lighting (art.6, comma 4)		
☐ Illuminated from the bottom towards the top	⟹	Replace with lighting from the top towards the bottom
Monuments and buildings (art.6, comma 10)		
☐ Generic monuments and buildings illuminated from the bottom towards the top	⟹	Replace with lighting from the top towards the bottom
☐ Subjects of proved historical and architectural value illuminated from the bottom towards the top with light beams oriented beyond the edges of the structure	⟹	☐ Replace with lighting from the top towards the bottom ☐ reorient the beams of light one meter under the upper edge of the structure and within its perimeter
☐ Total or partial switch off	⟹	Within 24.00 hours
Flow reducers (art.6, comma 2)		
☐ New installations not realized with flow reducer	⟹	Insert a system for the reduction of the flow not lower than 30%, within the hours 24
☐ Installations equipped with flow reducers which intervene after the hours 24, and/or reductions of the flow higher than 30%	⟹	Adjust the regulator of the light flow to intervene within the hours 24 and with a maximum residual flow of 30%.
Beacons (art.6, comma 10)		
☐ Rotary or fixed beacons for pure advertising purposes have been installed	⟹	Immediate removal

..* 00462

PRE-EXISTENT INSTALLATIONS IN THE PROTECTED AREAS

INDICATIVE TABLE FOR THE ADJUSTMENTS OF OUTDOOR LIGHTING INSTALLATIONS ACCORDING TO R.L. N.17/00 OF THE LOMBARDIA REGION AND RELATED REGULATION

VIOLATION ASSESSMENT FORM N. _____

Locality/Street _____
Municipality _____

VERIFIED VIOLATION		RECOMMENDED ADJUSTMENT
Within 4 years from coming into force of the law (art.9, comma 1)		
Lamps - High efficiency (art.9, comma 1) ☐ Low efficiency lamp such as mercury-vapours lamps or fluorescence lamps	⟹	☐ Replace with high efficiency lamps >100 lm/W such as high- or low-pressure sodium lamps ☐ If the above is not possible, replace the devices
Road floodlights - (art.9, comma 2) ☐ Installations dispersing more than 0 cd/klm at 90° and beyond	⟹	☐ replace with full cut-off optics and lamp recessed in the upper part of the device in order to keep the light dispersion less than 0.49 cd/klm at 90° and beyond ☐ install suitable shields, replace or remove the optics protective cups with flat glass (if possible with the lamp recessed in the upper part of the device) in order to keep the light dispersion less than 0.49 cd/klm at 90° and beyond
Urban fittings and higly polluting devices - (art.9, comma 4) ☐ higly polluting devices (such as globes, lanterns or similar) dispersing more than 15 cd/klm at 90° and beyond	⟹	Must be: ☐ replaced with devices dispersing max 0.49 cd/klm at 90° and beyond ☐ shielded or however equipped with suitable devices to contain and direct to the ground the light flow and provided with transparent protective glasses) in order to keep the light dispersion less than 0.49 cd/klm at 90° and beyond
Beacons, beacon-towers and car parks - (art.9, comma 5) ☐ Floodlights dispersing more than 0.49 cd/klm at 90° and beyond	⟹	Replacement option: ☐ must be replaced with devices having the specified parameters (max 0.49 cd/klm at 90° and beyond) ☐ If sufficient, and the safety is not compromised, change the inclinations of the floodlights equipping them with horizontal flat glass
Signboards of not specific and indispensable nocturnal use - (art.9, comma 4) ☐ They are lit after the hours 23 (in winter) and hours 24 (in summer)	⟹	☐ They must be shut off after the hours 23 (in winter) and hours 24 (in summer)
Flow reduction within the hours 23 in winter, hours 24 in summer - (art.9, comma 3) ☐ Installations not equipped with light flow reducers	⟹	Replacement option: ☐ without changing the conditions of safety, switching off of 50% of the light sources ☐ insertion of a suitable system for the reduction of the light flow

Annex H

INSTALLATION
DECLARATION of CONFORMITY TO THE R.L. 17/00

The undersigned ..... company's titular or legal representative

..... working in the sector ... ...

with place of business in street ..... n° ..... CAP .....

Town ..... prov. ..... tel. .....

fax ..... VAT No. .....

❑ registered on the register of the companies (R.D. 9/20/1934 n° 2011) of the C.C.I.A.A. of ... ...

..... al n° .....

❑ registered on the provincial register of the artisan enterprises (law 8/8/1985, n° 443) of ... ...

..... at the n° .....

executor of the plant (schematic description): .....

.....

.....

.....

understood as: ❑ new plant ❑ transformation ❑ widening
❑ extraordinary maintenance ❑ other .....

realized at: ..... town: .....

DECLARES

under its personal responsibility than the plant was realized in accordance with the Lombardy Region law no. 17 of 03/27/00 object "URGENT MEASURES TO FIGHT THE LIGHT POLLUTION AND TO ACHIEVE ENERGY SAVING IN THE USE OF OUTDOOR LIGHTING" artt. 6 and 9, and related Accomplishment Regulations, considered the conditions of exercise and the uses to which the installation place is destined, having in particular:

❑ respected the executive project arranged by enabled technician corresponding to the R.L. 17/00;
❑ followed the suppliers' indications for the conformity to the R.L. 17/00;
❑ respected the technical provisions applicable to the use .....
❑ installed the electric components in pursuance to the law 46/90 and other current laws;
❑ installed materials and components duly built up and suitable for the installation place;
❑ checked the installation for safety and functionality with positive result having executed the verifications requested by the buyer, by the rules and the law dispositions.

Annexes:

❑ ..... ❑ .....
❑ ..... ❑ .....

DENY

any responsibility for accidents to people or things deriving from tampering of the plant by third or from maintenance or repair shortages.

Date .....

The declaring

.....

Annex I

Example of product conformity declaration

[MANUFACTURER'S OR IMPORTER'S HEADED PAPER]

Declaration of Conformity

To the Lombardy Regional Law n ° 17 of March 27th, 2000

With reference to the request as from our Ref. n. _____

The firm : .....

declares under its own responsibility that the product pertaining to the series or model:

[PRODUCT NAME]

Equipped with lamps: [POWER AND LAMP TYPE]

Credited laboratory:

Tested in the laboratory	
Technical person in charge	

Test parameters:

Measure system:
Position of the device during the measure:

Device:

Type of reflector		Type of shield	
Measure parameters		Environment temperature	
Supplying tension		Frequency	

Reference rules:

UNI 10671	Photometric data measurement and presentation of the results
PrEN 13032	Measurement and presentation of photometric data and luminairs
CIE 27	Photometry luminaires for street lighting
CIE 43	Photometry of floodlights
CIE 121	The photometry and goniophotometry of luminairs

If installed as specified in the instructions sheet,

Is corresponding To The R.L. 17/00 of 03/27/01 and related accomplishment regulations

and in particular to the article 6 comma 2 of the above-mentioned law, since the device in its installation position has a maximum light intensity of 0 cd for 1000 lumen at 90° and beyond; furthermore the same is equipped with lamps with the highest possible efficiency (high- or low-pressure sodium vapours or, where is only absolutely indispensable a high chromatic yield, metal-halogen lamps, compact fluorescence or white-light-sodium lamps in relation to the type of application).

[Place], [DATE]
[THE MANUFACTURER OR IMPORTER]

Annex L

Example of Town-council's ordinance for the switching off of advertising light beacon as advertising "lasers"(provisions already adopted by several councils): (Desenzano, S.Vittore Olona, Lovere, etc).

CITY OF .....

Ordinance No..... of .....

THE MAYOR

Recalled the art. 23 of the New Code of the Road Gov. Decree 04/30/1992, n.285 and his next modifications and integrations, according to which for effect of the paragraph 1, "Along the streets or in view of them it is forbidden to place". . omissis .... " installations of advertising or promotion, horizontal publicity signs, light sources visible from the vehicles travelling on the roads, which can cause visual trouble to the users of the road or divert their attention with consequent danger for the safety of the circulation";

- **Recalled** the article 6 paragraph 9 of the Regional Law 03/27/00 no. 17 having for object "Urgent measures to fight the light pollution and to achieve energy saving in the use of outdoor lighting", which "expressly prohibited the use of rotary or fixed advertising beam-light or beacons of whichever type, for the mere advertising aim" and the article 1 paragraph 2 and article 6 paragraph 2 of said law which states that any light emission beyond the horizon is forbidden;

- **Verified** that it is by now a well-established and diffuse habit to install, usually in correspondence of premises which develop their activity at night, powerful beacons, usually rotating, which during the night time project beams of light towards the outside and the sky, visible also from large distances, aimed to identify and locate the presence of said premises and to attract the attention of the citizens and of the users of the road;

- **Recognized** the necessity to prohibite the installation and the use of such light sources, on the whole municipal territory;

- **Noticed** that such light sources, due to their nature, the specifications and characteristics above mentioned, are source of light pollution and disturb of the environment and can cause visual trouble to to the users of the road and divert their attention with consequent danger for the safety of the circulation;

- **Considered** the art. 50 of the Government Decree no. 267 of 08/18/2000;

ORDERS

As a caution, the immediate prohibition of installation of new light sources, as shown by the regional law 17/2000, that is in case of already installed ones, the immediate prohibition of ignition of the sames since the moment of the notification of the present provision.

INFORMS

That for any violation of the present dispositions, the endorsements indicated in the art. 8 of the Regional Law of 03/27/2000 n.17 will be applied, together with, if the case, those indicated in the article 23 of the Gov. Decree of 04/30/1992 no. 285 and next modifications and integrations.

ASSIGNS

to the personal delegate to the service of Road Police as indicated in the article 12 of the Gov. Decree 04/30/1992, no. 285 the task to verify the respect of the present document;
To the Municipal Technical Office and to the Command Of Municipal Police the execution of the present ordinance for what of their competence.

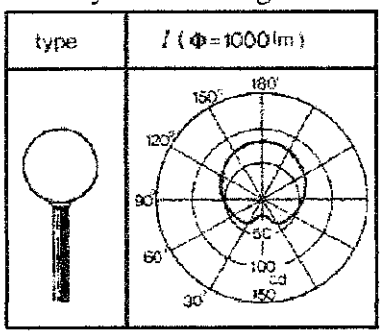
The Mayor

.....

Annex M

Photometric curves - how to read and understand them

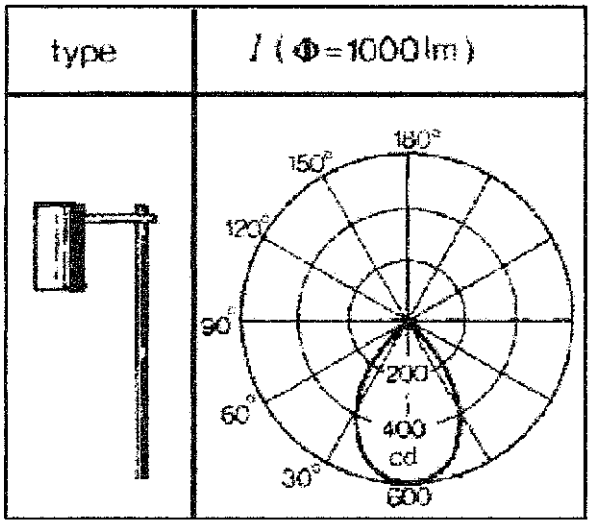
The photometric curve represents graphically how a light source emanates light in the surrounding space. That is in what direction the light is emanated and which is its intensity.
To any object which issues light can be associated a photometric curve, is it a simple bulb, a lighting device or a screen reflecting the light. The photometric curve of a lighting device allows to establish its impact on the surrounding environment.
In order to build a photometric curve it is necessary to measure the light intensity. In practice it is necessary "to see" which intensity is emitted by the considered light source in a determinate direction. It is as, turning around the device looking though different angles, we measure the intensity of emitted light.



The measurement shown in the drawing refers to a spherical device which pratically issues the light in all the directions even if with different intensities; in fact the higher intensity is sent upwards, at 180°, while downwards at 0° we have the lowest intensity, certainly due to the presence of the pole which supports the sphere. It is evident that spheres of this type are not very effective lighting devices and that they illuminate exactly where they must not do it. Looking at the photometric curve, the behaviour of the device is obviously perceived. In the diagram the rays show the direction in which the light is sent and the concentric circles show the related intensity. Graphically verifying the intensity of light emitted in every direction is simple: for instance see which light intensity is sent at 90°. The line representing the photometric curve intersects the circle marked by the number 50 cd (arrowed). At 90° (horizontally) the globe therefore sends the light with an intensity equal to 50 candles every 1000 lumen. Lumen represent the amount of light issued by a light source and is technically called "light flow". This parameter allows to free the photometric curves from the type of lamp used in a given device and from its power; in fact expressing the quantities in lumen (precisely 1000 lumen), the globe will issue the light any way with various intensities (according to the power and the lamp) but always in the same way: a lot of light above, little light below.
Then if we use, for instance, a high pressure sodium-ellissoidale bulb lamp of 100 W nominal power, which has a light flow of about 10.000 lumen, the light intensity at 90° will be equal to 50 x 10.000/1.000 = 500 candles.
Let's try to read from the photometric curve of a spherical lamp which is the light intensity emitted at 180°. The photometric curve almost passes halfway between the circle marked "50" and that marked "100". It would say what in that point the light intensity is equal to 80 candles/1000 lumen, more or less. Certainly we noticed the value in an a little unsure way; to make the reading more precise the photometric curve is always taken by a table which shows us the exact values avoiding to have to identify them in a graphical way. The table associated to the photometric curve of the sphere could be this:

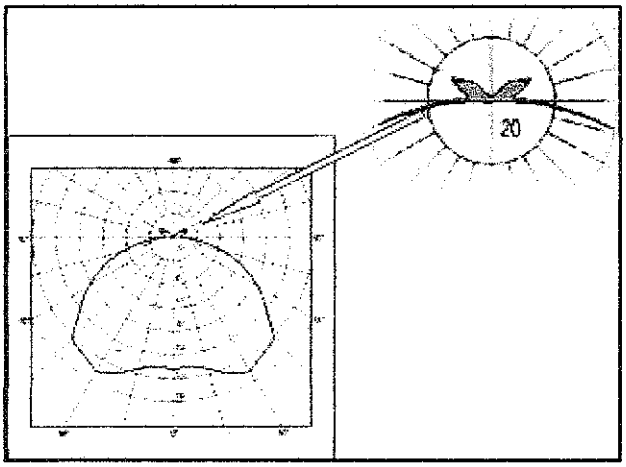
Angle	Intensity / 1000 lm
0°	25
30°	35
60°	45
90°	50
120°	68
150°	75
180°	80
210°	75
240°	68
270°	50
300°	45
330°	35

Let's now examine the photometric curve of the device shown here. This table



We can guess that the device issues all his light downwards and almost exclusively in the range from 330° and 30° or, if you like, between the -30° and the +30°. Most of the emitted light is concentrated in this cone of 60°. Then we can notice that the concentric circles quote much higher values than those in the photometric curve of the spherical lamp: the values shown are 200, 400 and 600. This device has the characteristic to concentrate the light within a given angle. Using the 100 W bulb as in the previous example, we would have a light intensity at 0° (vertically on the ground) equal to 600 x 10.000/1.000 = 6.000 candles much higher than the 25 x 10.000/1.000 = 250 candles produced by the sphere (see related diagram).

Looking at the two photometric curves it is possible to draw the following conclusions: the spherical device emits low light intensities in all the directions, mainly upwards; the cylindrical device, instead, emits very high light intensities downwards and concentrated in a 60° arc.



How to distinguish the photometric curve of a device corresponding to the R.L. 17/00 requirements?
In the example here reported, if the examined photometric curve is that of an outdoor lighting device, such curve is NOT in accordance with the R.L. 17/00; it is possible to notice that a little component of the emitted light is sent in the upper hemisphere (at beyond 90° and over the horizon).
In particular the R.L. 17/00 and its accomplishment regulations allow light emissions at 90° and beyond of maximum intensity of 0.49 cd/klm, which is an amount verifiable exclusively reading the measurements in tabular form.

In order to verify the conformity of a device to the requirements of the R.L. 17/00, it is not enough a summary vision of the photometric curve, which could be easily manipulated or "cut" beyond the 90° (as sometimes it happens in a few catalogues), but it is indispensable to obtain and verify the table of the luminance values concerning said curve, since low levels of luminance, may not be readily identifyable in the graphic representation of the photometric curve. Even the tables do not give the absolute certainty of the truthfulness of the data; greater security may be achieved requiring photometric data certified from third parties, such as, i.e., the "Performance Label" released by the Italian "Marks of Quality Institute" (IMQ) or other european Institute.

Inclination of the lighting devices

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A further interesting aspect is represented by the fact that devices without light emissions for angles greater than 90° (thus corresponding to the R.L. 17/00 requirements) are sometimes installed in an inclined position with respect to the measure position (that is, in the laboratory). In such a case, the photometric curve is rotated on the axis of the diagram, according to the inclination angle. To know the new associated photometry, proceed as follows:

1. Analyse the table associated to the device (horizontal position) figure 1
2. If the device was oriented with 10° inclination, the values would shift of a position, corresponding to 10° (see figure 2)
3. If the device was oriented with 30° inclination, the values would shift of three positions, corresponding to 30° (see figure 3)

Fig. 1

Angle	Intensity cd/1000 lm
0°	335
10°	368
20°	391
30°	412
40°	435
50°	487
60°	574
70°	125
80°	12
90°	
100°	
110°	
120°	
130°	
140°	
150°	
160°	
170°	
180°	
190°	
200°	
210°	
220°	
230°	
240°	
250°	
260°	
270°	
280°	12
290°	125
300°	574
310°	487
320°	435
330°	412
340°	391
350°	368

Lighting devices allowable for R.L.17/00

Fig. 2

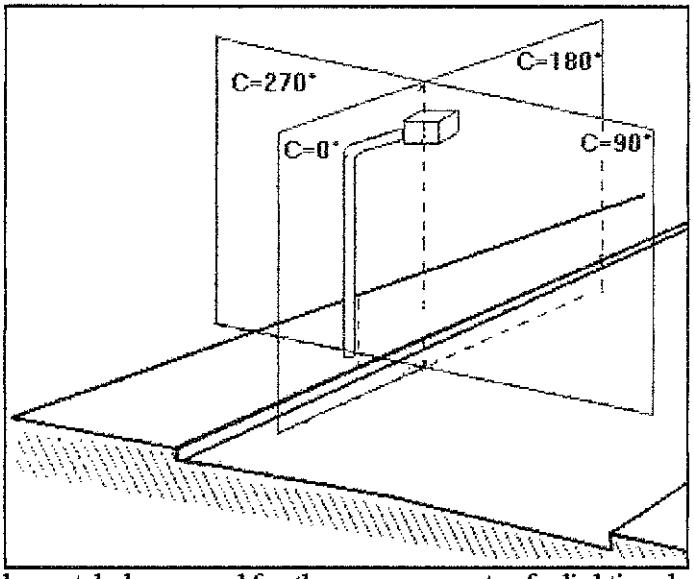
Angle	Intensity cd/1000 lm
0°	368
10°	335
20°	368
30°	391
40°	412
50°	435
60°	487
70°	574
80°	125
90°	12
100°	
110°	
120°	
130°	
140°	
150°	
160°	
170°	
180°	
190°	
200°	
210°	
220°	
230°	
240°	
250°	
260°	
270°	
280°	0
290°	12
300°	125
310°	574
320°	487
330°	435
340°	412
350°	391

Lighting devices not allowable for R.L.17/00

Fig. 3

Angle	Intensity cd/1000 lm
0°	412
10°	391
20°	368
30°	335
40°	368
50°	391
60°	412
70°	435
80°	487
90°	574
100°	125
110°	12
120°	
130°	
140°	
150°	
160°	
170°	
180°	
190°	
200°	
210°	
220°	
230°	
240°	
250°	
260°	
270°	
280°	0
290°	0
300°	0
310°	12
320°	125
330°	574
340°	487
350°	435

Lighting devices not allowable for R.L.17/00



Fundamental planes used for the measurements of a lighting device

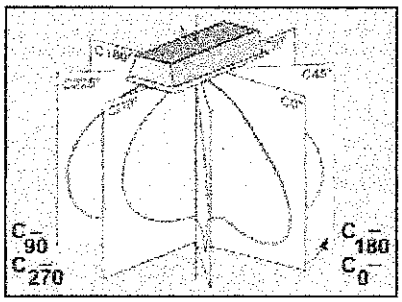
The manufacturers of lighting devices are able to provide tables which allow to get the measured value of the light intensity emitted to every γ angle (gamma). In particular these tables of lighting devices photometric data are realized and certified by opportune specialized laboratories of third parties. For instance the Italian "Marks Quality Institute" (IMQ) introduced the Quality Label "Performance", which can be useful to verify if the device is corresponding to the R.L. 17/00 even for values of γ greater than 90° (see table).

Table of lighting device light intensity (cd/klm) extracted from IMQ "Performance" certificates

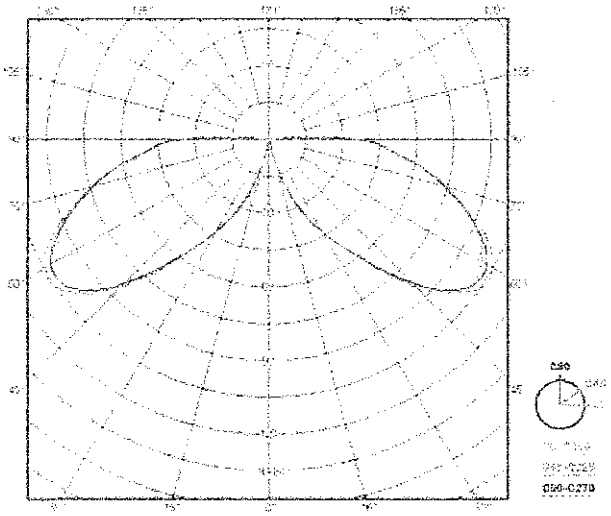
C γ	270	285	300	310	315	320	325	330	335	340	345	350	355	360	5	10	15	20	25	30	35	40	45	50	60	75	90
0	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
10	186	186	187	188	190	190	190	190	191	190	191	192	192	193	193	193	195	195	195	194	194	194	193	193	193	193	188
20	177	177	179	182	184	187	188	191	191	192	194	197	198	200	200	199	202	203	203	194	195	194	192	190	185	184	182
30	160	163	168	173	176	181	185	186	190	194	200	204	206	214	214	212	214	211	207	206	196	192	180	184	173	169	173
35	150	154	160	167	171	176	180	183	187	195	201	209	212	215	215	215	215	211	207	200	196	186	180	178	165	160	167
40	130	144	152	158	164	170	176	180	178	193	194	204	207	210	210	223	227	227	210	196	185	177	173	169	155	150	158
45	125	134	146	155	157	160	165	171	178	186	193	200	210	225	225	230	236	236	219	201	186	174	168	162	150	142	155
47.5	116	123	134	145	151	159	163	169	178	191	196	201	215	230	230	240	257	257	237	205	186	169	163	157	142	135	145
50	106	114	127	136	142	140	157	166	176	188	198	210	221	235	235	256	284	284	284	211	182	162	152	147	133	126	136
52.5	96	104	120	128	135	142	151	162	173	187	200	215	231	240	240	279	309	309	282	217	173	157	146	140	128	120	128
55	90	99	113	121	126	135	143	155	166	180	197	215	235	245	245	303	334	334	285	223	173	150	142	136	121	114	121
57.5	82	83	104	114	120	128	133	139	153	165	184	210	241	255	255	325	352	352	282	225	163	142	134	130	112	106	114
60	76	84	96	106	110	117	120	126	140	155	175	207	250	263	263	340	364	364	284	225	161	138	128	122	104	95	106
62.5	68	76	86	97	101	107	110	114	128	145	168	199	254	267	267	346	341	341	277	223	161	134	122	105	97	85	97
65	62	68	80	90	94	99	104	110	121	138	156	190	218	257	257	359	393	393	263	222	159	127	114	100	91	77	90
67.5	53	63	73	83	87	92	96	102	115	134	152	179	210	247	247	346	350	340	231	227	150	117	106	93	85	71	83
70	36	47	67	74	78	82	85	91	104	126	150	177	204	241	241	324	343	333	200	215	134	101	87	84	76	65	74
72.5	10	29	50	59	65	71	74	77	93	115	142	168	190	219	219	312	320	270	164	188	111	80	52	60	51	51	59
75	5	8	19	29	35	43	47	65	66	97	120	151	160	168	168	279	275	185	51	144	59	33	41	34	22	27	29
77.5	2	4	6	7	9	11	12	12	20	38	60	82	80	77	110	188	124	44	8	86	17	7	8	8	5	14	7
80	0	1	3	4	4	5	8	6	7	7	8	11	12	13	20	85	13	6	4	27	9	3	7	2	1	2	4
82.5	0	0	0	0	0	0	1	1	1	2	2	2	2	2	4	13	5	3	1	5	2	1	1	1	1	1	0
85	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	4	2	1	1	2	1	0	0	0	0	0	0
87.5	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	2	1	1	0	1	0	0	0	0	0	0	0
90-180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NB. Verify that tables were not "cut" since it is cumbersome and not very interesting for who is not responsible for light pollution to report also the values for γ angles greater than 90° .

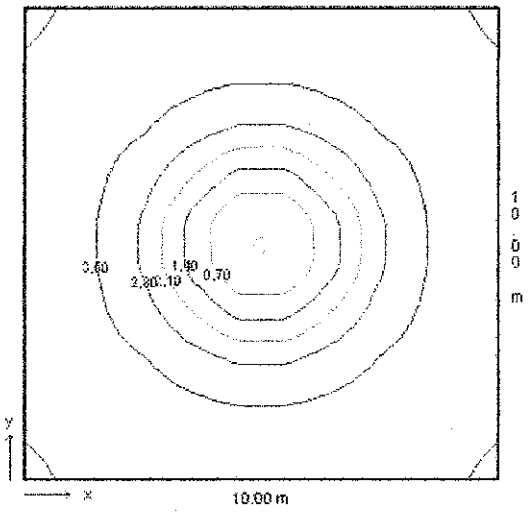
Asymmetrical optics



In the photometric curves previously analysed, only one graphic line is reported, representing light emission of the in the various vertical slopes. This representation is sufficient if the light source or device we are analysing is a symmetrical one. A symmetric device sends the same light intensities in every direction (if seen from above) and then also on different planes. If we look a spherical lighting device frontally, the light intensity we would measure would be always the same, even if we observe it from a side or behind. The spherical lighting device is a typical example of symmetric device. If we calculate the illumination (expressed in lux) produced on the soil using a symmetric photometric curve, we will certainly obtain a series of circular and concentric isolux lines (with the same lux value).

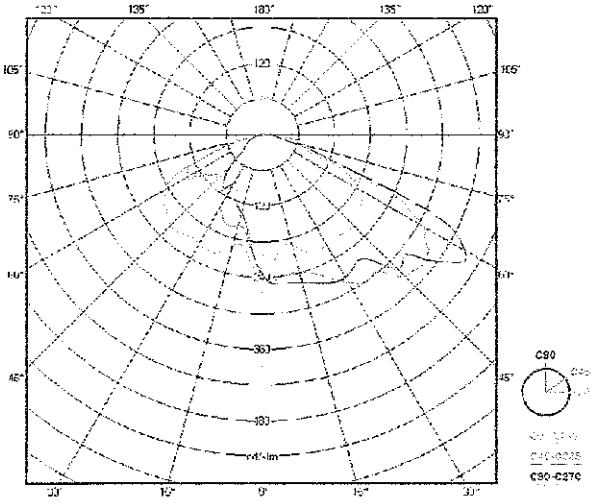


Simmetrical optics
(same mesured on 3 planes)

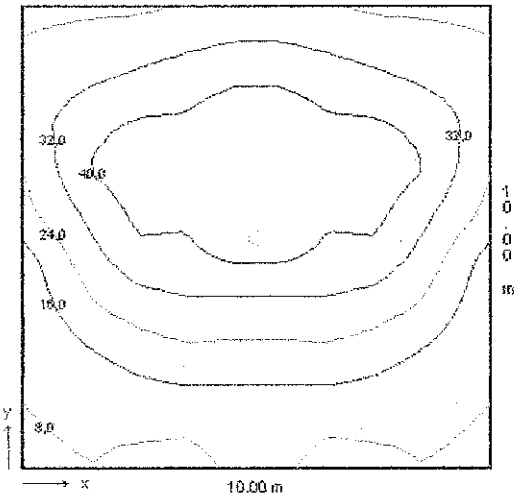


Circular Isolux level

Unlike the symmetric sources, asymmetrical devices give no more circular isolux curves, when observing the light projected on the soil as in the previous example.



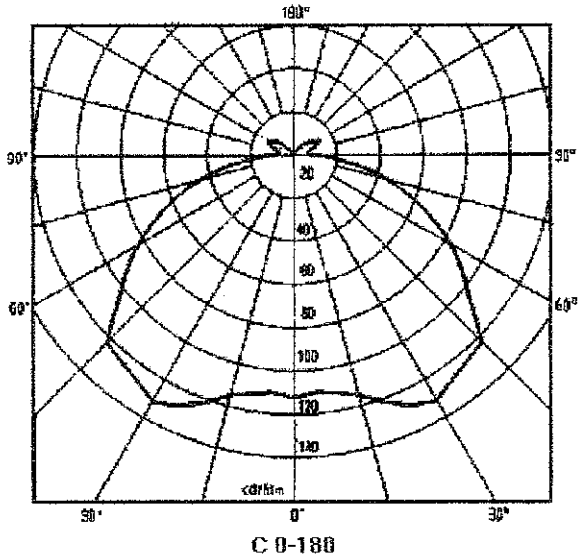
Fotometric curve for Asymmetrical optics
mesured on 3 planes



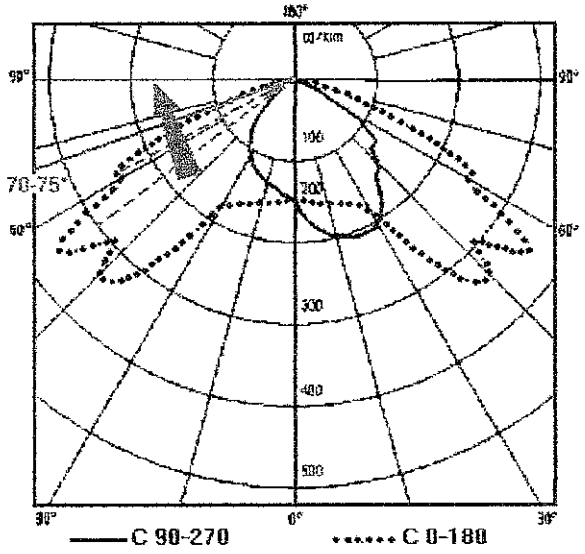
Irregular Isolux level

Shape of the photometric curve

The shape of the photometric curve is important to understand in an intuitive way the behaviour of the device we are analysing. In case of devices destined to road lighting (floodlights), it is very important that the photometric curve sends the light only in the interested directions (along the axis of the road and not beyond it) and with the right light intensity (as much as possible uniformly distributed). If we'd like to install the smallest number possible of devices, it is evident that these should "widen" the most possible the light beam. "To widen" here means to send sideways a lot of light, hence with high intensity, referring to the plane (C=0° - C=180° of the drawing in the previous page). Vertical to the floor, the necessary light level is lower. On the plane (C = 90° - C = 270°), instead, it will be important noticing that highest light intensity be towards the side to be lit up, comprised between 0° and 90°.



Lighting curve device without hight peformance



Hight peformance lighting curve with hight extension on the C 0-180 plane, near 70-75°.

Devices manufacturing companies take care of what above stated, when studying the most efficient optics. Lighting devices development aims to the reduction of light points. Obtaining high uniformity coefficients leads to better results in terms of visual perception. Roads with less light intensity but better uniformity parameters are definitely to prefer to high illuminated streets with poor uniformity. Another point to consider is the asymmetry necessary to guarantee the maintenance of the qualitative parameters even with simple and economic lighting installations realized only on one side of the carriageway. To avoid taking the lighting device towards the center of the carriageway, usually by the classical whip poles, it is better to work on the optics pushing the light, besides sideways (right and left), also in depth (ahead). The introduction of this further asymmetry allowed to take back the device on the border of the carriageway, like the classical application on straight pole (see the solid-line curve above right).

The shape of the curve on the plane C0 ° - C180° is still the most important parameter in the choice of most efficient devices. The ideal curve should have a downwards light intensity sufficient to obtain the required level of illumination, then as angles increase intensity should accordingly increase; in fact, as the distance between the light source and the surface increases, higher light intensity is necessary, not forgetting that the request of more light increases as light inclination increases. It is necessary that light emission stops at inclinations of more or less 70°. Is important it collapses very quickly, the so-called clean cut of the light, better known as cut-off. The emission of light intensities beyond such slopes is no more effective and can turn out counterproductive due to dazzling effects on the observers.

Annex N

Efficient Outdoor Lighting
Information Sheet 52, January 1999 - http://www.darksky.org/ida/ida_2/info52.html

The efficient and effective use of electrical lighting outdoors can offer major energy and cost savings. This information sheet suggests some of the things that can be done. Most of the suggestions apply to indoor lighting as well, where they also offer significant savings. There are several clear cut measures that can be taken to improve energy savings. New, much improved light sources are now available which provide considerably more light per unit of energy. Most newer fixtures offer better light control, putting light where it is needed rather than wasting a great deal of the light produced by the lamp. Replacement of older fixtures and lamps with the newer, improved ones can greatly improve efficiency.
Lamp efficiency is measured in lumens per watt. A lumen is a unit for measuring the amount of light; a watt is a unit for measuring the amount of electrical energy used.

The lamp that gives the most lumens per watt is the most efficient lamp. The table below lists the lighting efficiency of some of the common lamps used for outdoor lighting:

Type of Lamp	Lumens per watt	Average Lamp Life (hours)
Incandescent	8 - 25	1000 - 2000
Mercury Vapor	13 - 48	12000 - 24000+
Metal Halide	60 - 100	10000 - 15000
High Pressure Sodium	45 - 110	12000 - 24000
Fluorescent	60 - 100	10000 - 24000
Low Pressure Sodium	80 - 180	10000 - 18000

Incandescent: It is the most common type of lamp used in homes, indoors and outdoors. It is the most energy inefficient of the common lamp types. It produces light by electrical energy heating a filament of fine wire that glows white-hot when the current flows through it. It produces a great deal of heat relative to the amount of light: only 10 percent of the energy goes to producing light. It has been called a heat source that happens to produce some light at the same time. The 40 watt bulb is often adequate for most outdoor lighting applications, such as a porch light, especially if it is used in a fixture that actually controls the light output rather than scattering it everywhere. Many existing fixtures are very inefficient and waste a good deal of the light (remember that the lamp is inefficient, too). Replace incandescent lamps with more energy efficient lamps in good fixtures. One can use compact fluorescent lamps in an efficient fixture, or for even more efficiency use a low wattage LPS lamp in a well-shielded fixture. Consider also time clocking any incandescent fixtures, as mentioned below.

Mercury Vapor: It is commonly used for a number of outdoor applications, such as "security" lighting, as well as indoors for some applications. It has a relatively long life compared to most other lamps, especially compared to incandescent. These lamps are a quartz tube filled with mercury gas under pressure. Light is produced when an electric current passes through the mercury vapor. Like all such high intensity discharge (HID) lamps, a "ballast" is required to start and to operate the lamps at the correct voltage and current levels. For savings, one can and should use the lowest possible wattage for the application. Many of the existing fixtures have a great deal of associated glare due to lack of adequate light control. With a good fixture, less light is wasted and lower wattages can be used. In a glare-free lighting environment, remarkably low light levels still give excellent visibility. It is in the high glare areas, even with much higher levels of lighting, that we have difficulty seeing well at night. When replacements are indicated, one should replace not

only the lamp but the entire fixture. Use a more efficient light source, such as MH, HPS, or LPS, and use a high quality fixture, one that directs the light output to the areas needed and one that is glare free. A cost analysis study will show remarkable energy saving potential. Metal Halide (MH): These lamps are used for both outdoor and indoor applications. Metal halide and fluorescent are now in a dead heat as the most energy efficient of the "white light" sources. Metal halide lamps produce light when an electric current flows through the gas within the lamp envelope. They are about twice as efficient as mercury lamps. Use this light source at night when it is necessary to render colors close to their daytime appearance. As with all light sources, one should not use more wattage than is necessary for the application. "More light" is not always better. In many applications, such overkill is counterproductive to visibility, especially if it is accompanied by glare.

High Pressure Sodium (HPS): Its main usage is outdoors, for street lighting, parking lot lighting, and other such applications. It is generally more energy efficient than metal halide and is a good choice when true color is not critical. The light produced is an orange-gold color. It's very common in the U.S.

Fluorescent: Like metal halide, fluorescent is about four times as efficient as incandescent lighting. Fluorescent is commonly used for indoor applications, but outdoor usage is increasing. The best fluorescent and compact fluorescent (CFL) sources have several advantages over metal halide: longer life, a much shorter warm-up time to full brightness, ability to switch them on and off several times each night without significantly shortening bulb life, and a white light that is spectrally much less polluting than that produced by metal halide. Disadvantages are: high brightness CFLs are not available, light output is diminished at low temperatures, and a lamp may not even start at very low temperatures.

Low Pressure Sodium (LPS): This light source is the most energy efficient of all, and it is an excellent choice when used with a quality fixture that controls the light output. The light is produced from glowing sodium gas within a tube, and so the LPS fixtures, for higher wattage lamps, are larger than the equivalent fixtures for HPS or MH. However, the LPS fixture is an excellent choice for street lighting, parking lots, and security lighting. There is no color rendering at all, but adequate color rendering is quite possible with system designs that also use a few MH or fluorescent fixtures to add a little white light. For equivalent fixtures (ones that offer the same amount of light and good light control), a 175 watt mercury vapor fixture could be replaced by a 100 watt HPS or a 55 watt LPS. The 35 watt LPS is equivalent to a 200 watt incandescent. It is easy to see that considerable energy savings is possible. Remember also that if the installation is glare free, a lower light level offers excellent visibility. More is not always better.

Lighting controls: Controlling when and where the lights are used, how long they are on, and how bright they are can all be a major factor in conserving energy. Devices range from a simple on/off switch to computers programmed to control lights automatically. Turn lights off when not needed. Use individual controls rather than lighting large areas off of one switch. Use timers. Don't burn outdoor lights in the daytime. Use photo-sensors when possible. Some of the newer applications use motion sensors for room light control, and such systems are also feasible for outdoor applications.

Maintenance: Finally, do not forget lamp and fixture maintenance as a factor. Keep the fixture clean from dust and dirt. Such contamination can reduce light output in some cases by up to 50 percent.

Cost Comparison Example: (Assume that a well-designed fixture is being used in these cases, so that the light output by the lamp is being efficiently utilized. A bad fixture could be wasting more than 50 percent of the lamp's light.) Compare a 175 watt mercury (these are generally found in poor fixtures!) to a 100 watt HPS and a 55 watt LPS lamp. All of these lamps are producing about 8000 lumens, quite a lot of light. These are wattages that would commonly be used for residential street lighting. We assume 4100 burning hours per year, from dusk to dawn, and 8 cents (U.S.A.) cost per

kilowatt-hour of electricity (KWH). The total wattage of the system includes the wattage used by the lamp and the ballast together. It is easy to see the potential savings achieved by utilizing efficient lamps.

Lamp Wattage	Total Wattage	KWH Use/Yr	Oper $/Yr	100 lamps	10000 lamps
175	208	853	$68.22	$6,822	$682,200
100	130	533	42.64	4,264	426,240
55	80	328	26.24	2,624	262,400

See IDA Information Sheets http://www.darksky.org/ida/ida_2/info04.html and http://www.darksky.org/ida/ida_2/info26.html for additional energy saving facts.

Annex O

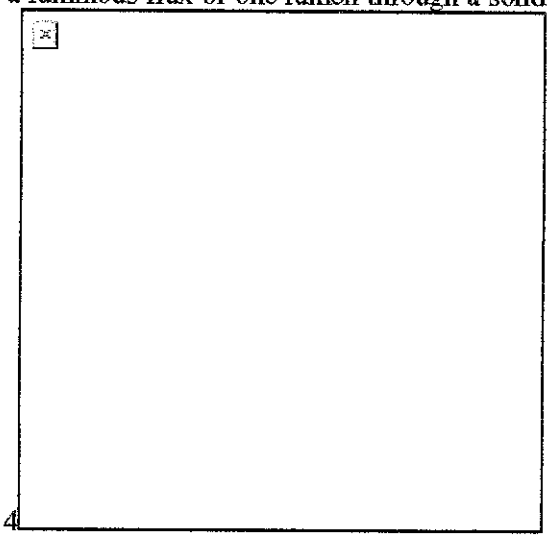
Glossary of Basic Terms and Definitions
Information Sheet 9, April 1997 - http://www.darksky.org/ida/ida_2/info9.html

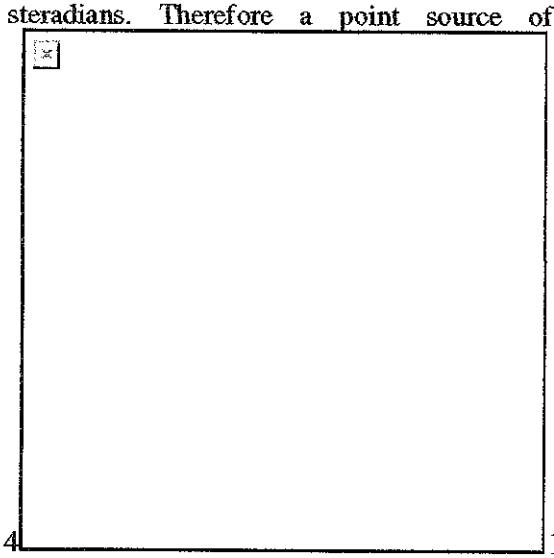
We include in this information sheet definitions for a number of the basic terms and words used in the lighting community. For further information and formal definitions, see discussions in standard dictionaries, encyclopedias, the IES Lighting Handbook, and other lighting industry books. Note that some of these definitions are quite subjective, and are offered here as a guidance, not as a formal definition.

Accent lighting: Lighting used to emphasize or draw attention to a special object or building.
Ambient light: The general overall level of lighting in an area.
Angstrom: A unit of wavelength often used in astronomy, equal to 10^{-10} meter or 0.1 nanometer.
Baffle: An opaque or translucent element to shield a light source from direct view.
Ballast: A device used with a discharge lamp to obtain the necessary voltage, current, and/or wave form for starting and operating the lamp.
Beam spread: The angle between the two directions in the plane in which the intensity is equal to a given percentage (usually 10 percent) of the maximum beam intensity.
Brightness: Strength of the sensation that results from viewing surfaces from which the light comes to the eye.
Bulb or lamp: The source of electric light. To be distinguished from the whole assembly (see luminaire). Lamp often is used to denote the bulb and its housing.
Candela (cd): The luminous intensity of a lighting source is measured in candelas. One candela is one lumen per steradian. Formerly called the candle. This is the basic unit of photometric quantity. The historical basis of the candela was associated with the amount of light emitted from the flame of a candle and was formerly known as one candlepower. The SI definition of the candela is "the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 X 10^{12} Hz and that has a radiant intensity in that direction of 1/683 watts per steradian".
Candlepower distribution curve: A plot of the variation in luminous intensity of a lamp or luminaire.
Candlepower: Luminous intensity expressed in candelas.
CIE: Commission Internationale de l'Eclairage. The international light commission. Sets many standards.
Coefficient of Utilization (CU): Ratio of luminous flux (lumens) from a luminaire received on the "work plane" [the area where the light is needed] to the lumens emitted by the luminaire.
Color rendering: Effect of a light source on the color appearance of objects in comparison with their color appearance under normal daylighting.
Cones and rods: Retinal receptors. Cones dominate the response when the luminance level is high, and provide color perception. Rods dominate at low luminance levels. No rods are found in the central part of the fovea. Rods have no color perception ability.
Conspicuity: The capacity of a signal to stand out in relation to its background so as to be readily discovered by the eye (as in lettering on a sign, for example).
Cosine law: Illuminance on a surface varies as the cosine of the angle of incidence of the light. The inverse square law and the cosine law can be combined.
Cut off angle, of a luminaire: The angle, measured up from the nadir (i.e. straight down), between the vertical axis and the first line of sight at which the bare source (the bulb or lamp) is not visible.
Cutoff fixture: A fixture that provides a cutoff (shielding) of the emitted light.
Dark adaptation: The process by which the eye becomes adapted to a luminance less than about 0.03 candela per square meter (0.01 footlambert).

Disability glare: Glare resulting in reduced visual performance and visibility. It is often accompanied by discomfort.
Discomfort glare: Glare that produces discomfort, but does not necessarily diminish visual performance.
Efficacy: The ability of a lighting system to produce the desired result.
Efficiency: A measure of the effective or useful output of a system compared to the input of the system.
Electromagnetic (EM) spectrum: The distribution of energy emitted by a radiant source, arranged in order of wavelength or frequency. Includes gamma-ray, X-ray, ultraviolet, visual, infrared, and radio regions.
Energy (radiant energy): Unit is erg, or joule, or kWh.
Fixture: The assembly that holds the lamp in a lighting system. It includes the elements designed to give light output control, such as a reflector (mirror) or refractor (lens), the ballast, housing, and the attachment parts.
Floodlight: A fixture designed to "flood" a well defined area with light.
Flux (radiant flux): Unit is erg/sec or watts.
Footcandle: Illuminance produced on a surface one foot from a uniform point source of one candela.
Footlambert: The average luminance of a surface emitting or reflecting light at a rate of one lumen per square foot.
Full-cutoff fixture: A fixture that allows no emission above a horizontal plane through the fixture.
Glare: Intense and blinding light. Never helps visibility.
HID lamp: In a discharge lamp, the emitted energy (light) is produced by the passage of an electric current through a gas. High-intensity discharge (HID) include mercury, metal halide, and high pressure sodium lamps. Other discharge lamps are LPS and fluorescent. Some such lamps have internal coatings to convert some of the ultraviolet energy emitted by the gas discharge into visual output.
High-Pressure Sodium (HPS) lamp: HID lamp where radiation is produced from sodium vapor at relatively high partial pressures (100 torr). HPS is essentially a "point source".
Illuminance: Density of luminous flux incident on a surface. Unit is footcandle or lux.
Illuminance (or illumination level) is defined as the amount of light being transmitted upon a certain area. The SI unit for illuminance is the lux, which is equal to one lumen per square meter. The Imperial unit for illuminance is the footcandle, which is equal to one lumen per square foot. Illuminance is governed by the inverse square law. The illuminance of an area or object diminishes as the square of the distance.
Illuminating Engineering Society of North America (IES or IESNA): The professional society of lighting engineers, including those from manufacturing companies, and others professionally involved in lighting.
Incandescent lamp: Light is produced by a filament heated to a high temperature by electric current.
Infrared radiation: EM radiation just to the long wavelength side of the visual.
Intensity: The degree or amount of energy or light.
International Dark-Sky Association (IDA, Inc.): A non-profit organization whose goals are to build awareness of the value of dark skies, and of the need for quality lighting.
Inverse-square law: Illuminance at a point varies directly with the intensity, I, of a point source and inversely as the square of the distance, d, to the source. $E = I / d^2$
kWh: Kilowatt-hour: A unit of energy equal to the work done by one kilowatt (1000 watts) of power acting for one hour.
Light pollution: Any adverse effect of manmade light. Often used to denote urban sky glow.
Light trespass: Light falling where it is not wanted or needed. Spill light. Obtrusive light.
Low-Pressure Sodium (LPS) lamp: A discharge lamp where the light is produced by radiation from sodium vapor at a relatively low partial pressure (about 0.001 torr). LPS is a "tube source". It is monochromatic light.

Lumen: Unit of luminous flux; the flux emitted within a unit solid angle by a point source with a uniform luminous intensity of one candela. One footcandle is one lumen per square foot. One lux is one lumen per square meter.
A point source of one candela intensity will produce a luminous flux of one lumen through a solid angle of one steradian. (A sphere has a total area of 4 steradians. Therefore a point source of one candela has a total luminous flux of 4 lumens). The lumen can be loosely interpreted as the amount of light emitted from a source with a certain intensity.





Lumen depreciation factor: Light loss of a luminaire with time due to the lamp decreasing in efficiency, dirt accumulation, and any other factors that lower the effective output with time.
Luminaire: The complete lighting unit, including the lamp, the fixture, and other parts.
Luminance: At a point and in a given direction, the luminous intensity in the given direction produced by an element of the surface surrounding the point divided by the area of the projection of the element on a plane perpendicular to the given direction. Units: candelas per unit area.
Luminance is the brightness of an object that has been illuminated by a source. The luminance of an object depends on its material characteristics and reflectance. For example, under the same illuminance conditions a dark object will look less bright that a light object. Since luminance refers to the amount of light reflected back by an object, this object in effect acts as a new source. There is a direct relationship between the luminance of a viewed object and the resulting illuminance of the image on the retina of the eye. The unit of luminance is the candela per square meter.
Lux: One lumen per square meter. Unit of illuminance.
Mercury lamp: An HID lamp where the light is produced by radiation from mercury vapor.
Metal-halide lamp: An HID lamp where the light is produced by radiation from metal-halide vapors.

Mounting height: The height of the fixture or lamp above the ground.
Nanometer (nm): 10^{-9} meter. Often used as the unit for wavelength in the EM spectrum.
Photometry: The quantitative measurement of light level and distribution.
Quality of light: A subjective ratio of the pluses to the minuses of any lighting installation.
Reflector: Controlling light output by means of reflection (mirror).
Refractor: Controlling light output by means of refraction (lens).
Semi-cutoff fixture: A fixture that provides some cutoff, but less than a full-cutoff fixture.
Spotlight: A fixture designed to light only a small, well-defined area.
Stray light: Emitted light that falls away from the area where it is needed or wanted. Light trespass.
Task lighting: Lighting designed for a specific purpose or task.
Ultraviolet "light": The energy output by a source which is of shorter wavelengths than the eye can see. Some photographic films are sensitive to ultraviolet energy, as are many electronic detectors. "Black Light."
Urban sky glow: The brightening of the night sky due to manmade lighting.
Veiling luminance: A luminance produced by bright sources in the field-of-view superimposed on the image in the eye reducing contrast and hence visibility.
Visibility: Being perceived by the eye. Seeing effectively. The goal of night lighting.

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CIE

COMISION INTERNACIONAL DE ALUMBRADO

INFORME TECNICO

RECOMENDACIONES PARA EL ALUMBRADO DE CALZADAS DE TRÁFICO MOTORIZADO Y PEATONAL

CIE 115:1995

UDC: 628.971.6
628.971.7

Contiene: Alumbrado Exterior
Alumbrado Viario
Alumbrado de Areas Urbanas

Este informe ha sido preparado por el Comité Técnico 4-15 de la CIE, División 4 "Alumbrado y Señalización para el Transporte" y ha sido aprobado por el Consejo de Administración de la CIE para estudio y aplicación. El documento informa sobre conocimientos y experiencias comunes dentro del campo específico de la luz y del alumbrado descrito, y está destinado a ser empleado por los miembros de la CIE y otras partes interesadas. Debe observarse, sin embargo, que este documento en una recomendación y no tiene carácter obligatorio. Deben consultarse los últimos informes o CIE NEWS, con respecto a posibles modificaciones posteriores.

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PROLOGO

Los siguientes miembros del TC 4-15 de la CIE "El alumbrado de calzadas para tráfico motorizado" han colaborado en la preparación de este informe. El Comité es parte de la División 4 de la CIE Alumbrado y Señalización para Transporte. Este informe Técnico ha sido aprobado por la División 4.

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CONTENIDO

RESUMEN

Este informe tiene por objeto la actualización de la publicación CIE 12,2 "Recomendaciones para el Alumbrado de carreteras para vehículos a motor" y la adición de recomendaciones para el alumbrado de las áreas conflictivas y las vías públicas frecuentadas por los peatones y otros usuarios

La Publicación CIE precedente ha aparecido en 1977 y desde esa fecha se ha adquirido una buena experiencia al nivel mundial en la aplicación del concepto de luminancia para el alumbrado de las vías públicas para los vehículos motorizados. Esta experiencia está reflejada en esta revisión. Las áreas conflictivas en las que ha aumentado el riesgo potencial de accidentes, están tratadas en detalle. Se proporciona un sistema de clasificación de dichas áreas y de las recomendaciones hecha en términos de Luminancia de calzada, pero para las aplicaciones en las que el empleo del concepto de Luminancia es inaplicable, se dan otras recomendaciones en términos de iluminancia sobre la calzada. Para el alumbrado de las zonas peatonales, se hacen recomendaciones en iluminancia y para ayudar a elegir el nivel adecuado se introduce un sistema de clasificación de estas zonas.

Se presentan dos conceptos relativamente nuevos: "Visibilidad de objetos pequeños" e iluminación semicilíndrica.

1. INTRODUCCION

Desde la publicación CIE Nº 12.2 RECOMENDACIONES PARA EL ALUMBRADO DE CARRETERAS PARA TRAFICO MOTORIZADO, publicada en 1.977 se ha adquirido una gran experiencia en todo el mundo en la aplicación del concepto de luminancia en el alumbrado de calzadas de tráfico. Esta experiencia ha sido utilizada para actualizar las recomendaciones en esta versión revisada del documento, que también tiene en cuenta las necesidades de otros usuarios de las calzadas, principalmente peatones y ciclistas.

Las recomendaciones están estructuradas con la intención de hacerlas fácilmente adaptables a las necesidades de cada País individualmente, de modo que puedan emplearse como la base para recomendaciones nacionales, códigos de buena práctica y normas.

En los Informes Técnicos de la CIE se hacen esfuerzos para conseguir el consenso general de los Miembros del Comité Técnico. Los Comités Técnicos trabajan con conceptos que están aún en una etapa de investigación y en los que, por la naturaleza del tema, de vez en cuando, no todos los miembros del Comité pueden estar de acuerdo en cada fase del informe. Se ha dado una descripción de tales dos conceptos que debido a su novedad, no han sido probados a una escala suficientemente amplia, ni durante un período de tiempo lo suficientemente largo, para ser recomendados sin reservas. Sin embargo, ofrecen potencialmente algunas ventajas por lo cual se incluyen. Estos conceptos son: *nivel de visibilidad e iluminancia semicilíndrica.* Se espera que los usuarios de este documento empleen estos conceptos sobre una base experimental cuando las circunstancias lo permitan. En particular, basados en sus propias investigaciones y experiencias, determinados países podrían adoptar el concepto del nivel de *visibilidad* como alternativa al concepto de *luminancia*.

Se publicarán actualizaciones del informe cuando se alcancen consensos sobre los temas aún en controversia, pero la CIE piensa que la presente solución de compromiso proporciona a todos los lectores interesados una visión del sujeto del alumbrado viario que progresa rápidamente.

De conformidad con la práctica más reciente de la CIE, las recomendaciones están basadas en niveles de alumbrado mantenidos y calidad de iluminación. En esencia esto implica que las prestaciones no deben caer por debajo de los límites prescritos, que son mínimos a lo largo de la vida de la instalación.

No se hace mención de garantías para decidir cuándo debe iluminarse una carretera. Para cada país esta decisión depende de muchos factores incluyendo circunstancias económicas, densidad de población, tráfico y tamaño. Como estos pueden variar mucho de país a país, no ha sido posible establecer líneas de guía de actuación.

2. PROPÓSITO DEL ALUMBRADO VIARIO

Hay tres propósitos principales del alumbrado viario:

1) Permitir que los usuarios de automóviles, de motocicletas, bicicletas y otros vehículos de motor o de tracción animal, circulen con seguridad.
2) Permitir que los peatones vean los peligros, se orienten por sí mismos, reconozcan a otros peatones y se les dé una sensación de seguridad.
3) Mejorar la apariencia nocturna dando del entorno o alrededores.

En el alumbrado de vías públicas necesita sopesarse la importancia relativa de estos elementos, particularmente en lo que se refiere al primero y segundo, ya que las necesidades de los conductores de automóviles y peatones difieren. El último propósito, que tiene un aspecto de amenidad, es importante para todos los usuarios de calzadas y residentes, tanto durante el día como durante la noche.

3. ALUMBRADO VIARIO PARA EL CONDUCTOR

El tráfico rodado continua creciendo de volumen por los avances tecnológicos, y las sociedades emergentes conceden una mayor fiabilidad al transporte por carretera. Aunque la mayor parte del tráfico se realiza durante las horas diurnas hay un considerable volumen de tráfico, en períodos de obscuridad. En algunos Países alrededor de un 25% de los viajes tienen lugar durante las horas nocturnas. La relación de accidentes de tráfico durante las horas nocturnas, sin embargo, es aproximadamente tres veces mayor que los ocurridos durante el día, debido fundamentalmente a la reducción de visibilidad durante la noche.

Los faros del coche satisfacen algunas de las necesidades requeridas durante la noche, pero llegan a hacerse progresivamente ineficaces con el incremento de la velocidad, número de vehículos o complejidad de la escena nocturna. Además, los faros deslumbran a los vehículos que circulan en sentido contrario, sobre todo cuando no hay instalación de alumbrado viario. Este problema se ve agravado en vías de tráfico rodado de doble sentido de circulación cuando los vehículos están muy próximos. La reducción del deslumbramiento de los faros puede conseguirse con la instalación de un buen alumbrado viario, el cual incrementa el confort y proporciona al conductor la posibilidad de ver detalles claramente y localizarlos con suficiente tiempo para reaccionar eficazmente.

Los criterios y valores específicos para un alumbrado viario de buena calidad son proporcionados en este documento. Estas recomendaciones están basadas sobre investigaciones y experiencias en todos los aspectos de los requisitos visuales durante la noche. Incluyendo la fisiología del sistema visual, factores humanos, (psicológicos) relacionados con las capacidades del conductor y las estadísticas proporcionadas por la instalación real. Es muy evidente que un alumbrado viario de buena calidad incrementa la seguridad (CIE 93-1992).

3.1 LA MISIÓN DEL ALUMBRADO VIARIO EN LA SEGURIDAD DEL TRAFICO MOTORIZADO

El propósito de un alumbrado viario es satisfacer las necesidades visuales y revelar obstáculos con el fin de posibilitar la circulación con seguridad. Mientras los faros de los coches y otros dispositivos de seguridad (marcas en la superficie de la calzada, líneas, señales, etc.) son de ayuda en el guiado del conductor, existe también la necesidad de revelar objetos extraños que pueden aparecer sobre la calzada o entrar en ella repentinamente.

La distancia requerida para frenar un vehículo con seguridad puede exceder a la distancia a la cual los faros del coche pueden revelar adecuadamente el objeto, dependiendo del tiempo de reconocimiento, reacción y frenado y factores tales como la velocidad del vehículo y si la superficie de la calzada, está seca o mojada.

Un alumbrado viario de buena calidad puede proporcionar la visibilidad requerida a distancia de modo que se pueda tomar la decisión de evadirse a tiempo sin que haya que efectuar una maniobra brusca.

El alumbrado viario fijo con sus habituales fuentes de luz en voladizo proporciona iluminación sobre la calzada y sus alrededores abriendo de este modo el campo de visión algo más, aproximándose a las condiciones de la luz de día. Este factor es de vital importancia en áreas con tráfico pesado y de alta complejidad visual donde puede haber diferentes tipos de usuarios de la calzada (tales como conductores, ciclistas, peatones y maquinaria agrícola de lento movimiento) presentes al mismo tiempo. Es también importante cuando hay trazados de la calzada con curvas.

Muchos estudios sobre porcentajes de accidentes confirman que éstos pueden ser reducidos en alrededor de un 30% cuando las áreas de accidentes sin iluminar son iluminadas conforme a estas recomendaciones (CIE 93-1992). La predicción de cambios en el porcentaje de accidentes como resultado de cambios en la norma de alumbrado viario es difícil y continúa siendo objeto de investigaciones.

4. CONDICIONES VISUALES CON LAS QUE SE ENFRENTA EL CONDUCTOR

4.1 General

El campo visual del conductor está formado por los carriles de circulación, los alrededores a cada lado, el paisaje visible y el cielo. Cualquier objeto acerca del cual es necesaria información, debe ser claramente presentado contra la parte del campo de visión que forma el fondo inmediato.

4.2 Condiciones urbanas

Los peatones son una parte importante de la escena. Están presentes en todos los tipos de vías de tráfico y son vistos contra diferentes fondos, tales como la calzada, edificios de los alrededores, o áreas abiertas, que pueden estar o no iluminadas. Cuando el fondo está iluminado, los peatones tienden a ser reproducidos en silueta, sin embargo, pueden aparecer algunos rasgos superficiales. De modo parecido el peatón puede ser visto en silueta inversa cuando el fondo es oscuro. La luminancia de los alrededores, que en áreas urbanas puede ser comparable a la de la superficie de la calzada puede reducir el efecto del deslumbramiento y las exigencias sobre control del deslumbramiento de las luminarias de alumbrado viario pueden ser menos restrictivas en estas áreas.

4.3 Condiciones rurales

Las áreas rurales están generalmente desprovistas de fondos iluminados, los cuales reducirían el deslumbramiento molesto. Las luminarias para alumbrado viario en estas situaciones requieren un control más estricto de la distribución de la intensidad luminosa en ángulos en que puedan ser vistas. Conducir por estas calzadas es usualmente más difícil debido a la variedad de problemas que pueden encontrarse; el tráfico es mixto y puede incluir peatones, ciclistas y equipos no motorizados.

4.4 Condiciones climatológicas

Los requisitos visuales proporcionados por una calzada iluminada pueden ser más fácilmente satisfechos en condiciones secas. En condiciones húmedas la luminancia de la calzada resulta menos uniforme y a veces con manchas. Esta condición lleva a incrementar la sensibilidad al deslumbramiento así como la producción de deslumbramiento procedente de las reflexiones superficiales brillantes de las zonas mojadas. Se necesitan requisitos de iluminación especiales para mejorar estos efectos en aquellas regiones en que la superficie de la calzada está mojada durante una considerable proporción del tiempo total (véase subapartado 6.7).

La niebla oscurece el campo visual dependiendo de su densidad. En autopistas, donde prevalecen las altas velocidades, esto puede dar lugar a situaciones peligrosas, particularmente si la niebla es desigual. La buena iluminación puede dar información en los alrededores inmediatos y guiado visual (apartado 4.7) con relación a la dirección de la calzada, particularmente en niebla iluminada.

4.5 Edad del conductor

La capacidad visual disminuye con la edad. Esto ocurre como resultado de tres efectos. Primeramente, la transmisión de los medios oculares disminuye con la edad; por ejemplo a los 70 años es sólo de un 28% con respecto a la de los 25 años. Segundo, la dispersión de la luz en los medios oculares se incrementa con la edad, lo cual reduce el contraste aparente de los objetos, de modo que por ejemplo, a los 70 años hay una media de 2'2 veces más dispersión de luz, expresada como la luminancia de velo equivalente, que a los 25 años. Como resultado de estos dos primeros efectos se necesita un umbral de contraste mayor para la percepción de objetivos por la persona mayor. De este modo un observador de 70 años necesita alrededor de tres veces más contraste en el umbral de visibilidad que uno de 25 años. En tercer lugar, la densidad del receptor en la retina disminuye con la edad, reduciendo por ello la capacidad del ojo para resolver detalles incluso aunque el ojo sea ópticamente correcto. Así, un observador de 70 años tiene una media de agudeza visual tan sólo del 66% de la que tienen los de 25 años.

Además, los procesos psicofísicos y de reconocimiento se reducen con la edad, de modo que los conductores mayores requieren más tiempo (y, por ello, más distancia) para tomar decisiones y reaccionar a las condiciones del tráfico.

Todos estos factores pueden tenerse en cuenta para conductores mayores que están representados en gran medida en las cifras de accidentes nocturnos incluso aunque estén representados como una pequeña proporción de conductores nocturnos.

En el establecimiento de los niveles de iluminación, se han tenido en cuenta estos factores.

4.6 La tarea del conductor y los requisitos visuales

Hay tres niveles en la tarea de conducción:

1. de posición
2. de situación
3. de navegación

Durante la conducción normal los tres son realizados simultáneamente. Cuando la complejidad de la tarea de conducción aumenta hay una tendencia a ignorar los niveles más altos (nivel 3 y luego nivel 2) para concentrarse en los niveles de menor orden.

Los tres niveles básicos se describen como sigue:

1) Nivel de posición: Conducción rutinaria o velocidad ajustada necesariamente para mantener una velocidad deseada y permanecer dentro del carril de circulación.

2) Nivel de situación: Cambio de velocidad, de dirección de desplazamiento, de posición en la calzada, requerido como resultado de un cambio en la situación geométrica, operacional o ambiental.

3) Nivel de navegación: Selección y seguimiento de una ruta desde el origen al destino de un viaje (CIE 100-1992).

Cada uno de estos niveles anteriores requiere clases de información visual particulares para permitir que la tarea de conducción sea realizada adecuadamente.

El nivel de posición requiere información visual en cada detalle tal como las marcas de las líneas de bordillo o cuneta de la carretera. Estas deben ser vistas con tiempo suficiente para mantener con seguridad la velocidad y la posición del vehículo. Este guiado visual es proporcionado por niveles de luminancia y uniformidad de luminancias adecuados.

El nivel de situación requiere información visual sobre la velocidad y cambios en la velocidad de los automóviles colindantes, espacios existentes y cualesquiera otros objetos de la calzada, de modo que se pueda continuar, parar y pasar. La capacidad de maniobrar con seguridad requiere que los objetos sean perceptibles a tiempo para que el conductor actúe confortablemente. La visibilidad de los objetos está relacionada con el nivel y la distribución de la luminancia en la superficie de la calzada. La luminancia media de la superficie de la calzada determina en gran medida el nivel de adaptación del ojo; en general, cuanto mayor es el nivel de adaptación causado por el nivel de luminancia de fondo, más sensible será el ojo al contraste y mejor será el rendimiento visual. La superficie de la calzada es la parte más importante del fondo y su luminancia, y no su iluminancia, determina el nivel de adaptación. Debido a esto, la luminancia es un criterio de calidad importante. La iluminancia en planos verticales transversales o paralelos a los ejes de la calzada, no obstante, puede en ciertas condiciones ser un útil complemento del valor de luminancia. La uniformidad de la distribución de luminancia en la superficie de la calzada es importante para proporcionar un fondo contra el cual los objetos y, en particular, las pequeñas partes de los objetos pueden ser observados.

Generalmente, cualquier información visual que permite al conductor maniobrar su vehículo con seguridad mientras esté ocupado en actividades de circulación es necesaria para el nivel de situación.

El nivel de navegación, además de una planificación previa del viaje, debe incluir información visual de las marcas, el entorno, cruces o intersecciones, señales de guiado, y otras fuentes formales de información. Este nivel requiere que el recorrido de las superficies de la calzada sea obvio, especialmente en intersecciones, bifurcaciones e intercambios. Las marcas de calzada tales como flechas e información de instrucciones también así como otros símbolos deben ser vistos con antelación para realizar apropiados movimientos de

navegación. La uniformidad y los niveles altos de luminancia de la superficie de la calzada contribuirán a este proceso visual.

Buenas condiciones visuales deben prevalecer sobre la completa escena de la vía pública para posibilitar que los diferentes niveles de las tareas de conducción sean ejecutados con seguridad. La facilidad de percepción dará como resultado menos tensión y estrés en los conductores y por tanto mejorará la preparación para enfrentarse al tráfico, condiciones geométricas, y eventos de medio ambiente inesperados.

Cuando un objeto plano tridimensional es visto contra la superficie de la calzada como fondo, entonces el contraste entre el objeto y el fondo puede estar influenciado por la geometría de la disposición de las luminarias y por su distribución de luz. Para objetos con una reflectancia difusa, especular o mixta, que producen una luminancia igual o mayor que la producida por un objeto de reflectancia difusa equivalente mayor de un 10%, el resultado puede ser una severa reducción, bien en el contraste entre el objeto y su fondo o bien un cambio en el tamaño de la zona de máxima luminancia sobre el objeto. Tales situaciones son apropiadas para producir condiciones visuales inaceptables sobre todo a partir de la escena de la vía pública.

Si el proyectista de alumbrado anticipa que tales objetos son probables que existan, entonces se debe hacer una evaluación usando un modelo de visibilidad tal como el descrito por Adrian (Adrian, 1989). Se recomienda que tal evaluación sea hecha si el proyectista trata de conseguir los valores de contrastes altos recomendados para los conductores mayores mencionados en el apartado 4.5.

La geometría de la instalación y la distribución luminosa de las luminarias deben escogerse para mejorar de otra forma las inaceptables condiciones de contraste.

4.7 Guiado visual directo

La luz directa procedente de las luminarias puede ayudar al conductor para delinear el recorrido de la calzada. Esto puede ser particularmente significativo en calzadas de trazado complejo y en cruces complicados, y en la niebla puede ser una contribución más útil de los sistemas de alumbrado.

4.8 Estudios de Alumbrado Público

Cuando desciende el nivel de iluminación, la agudeza visual, la sensibilidad al contraste, el juicio sobre las distancias, la velocidad de visión, y la discriminación del color resultan perjudicados, y como el tamaño angular del objeto es reducido (debido a que, por ejemplo, necesita ser visto desde un poco más lejos en una calzada de alta velocidad), las necesidades de nivel de iluminación se incrementarán. Puede conseguirse extensa información sobre percepción visual de los bien conocidos manuales (Yves le Grand, 1952; Moon, 1961). La investigación básica ha demostrado que el deslumbramiento es de dos tipo distintos: molesto y perturbador. Los parámetros básicos que influyen en la magnitud de estos efectos están bien establecidos (Holladay, 1927; Hopkinson, 1940; de Böer y Schreuder, 1967; CIE 31-1976).

Para encontrar las condiciones de iluminación que darán tanto fiabilidad como fácil rendimiento visual en la situación de la calzada detallada antes, se han llevado a cabo un gran número de estudios en muchos Países en condiciones simuladas y reales usando tanto métodos subjetivos como objetivos. El contraste necesario para ver objetos estándar ha

sido obtenido de modo fiable (Dunbar, 1938; de Böer, 1951) y se ha usado para desarrollar el concepto de poder revelador. Esto ha hecho posible obtener la luminancia de calzada y alrededores necesarias para que los objetos tengan una distribución dada de reflectancias para ser vistos (Waldram, 1938; Hornes y Christie, 1961; Fisher, 1968; Hentschel, 1971). Se ha establecido la relación entre la fiabilidad de la percepción, la luminancia de la calzada y la uniformidad (Narisada, 1971). Los efectos del deslumbramiento molesto sobre el rendimiento y su necesaria restricción han sido analizados (Christie y Fisher, 1966).

El efecto de la luminancia de la calzada y su uniformidad en la facilidad de percepción ha sido estudiado usando estimaciones técnicas en modelos e instalaciones reales de carreteras (de Böer y Knudsen, 1963; de Böer, 1967; Walthert, 1973).

La fiabilidad y facilidad de percepción obviamente conducen a condiciones confortables. No obstante, la relación entre confort y deslumbramiento molesto ha sido formalmente estudiada con gran profundidad, usando métodos de estimación en simulaciones tanto de calzadas estáticas como dinámicas (Adrian y Eberbach, 1956; de Böer y Schreuder, 1967; Adrian y Schrender, 1970) y en instalaciones reales de vías públicas en varios Países (CIE 31-1976); Cornwell, 1973).

5. CRITERIOS DE CALIDAD Y CLASES DE ALUMBRADO PARA TRAFICO MOTORIZADO.

5.1 Criterios de calidad para iluminación de calzadas.

El sistema más generalmente usado para seleccionar los criterios de calidad para la iluminación de calzadas para tráfico motorizado está basado en el concepto luminancia, aunque antiguamente se usaba la iluminancia en algunos Países, pero la experiencia mostró que esto era un criterio insatisfactorio. En la aplicación del concepto de luminancia el propósito es crear una superficie de calzada brillante contra la cual los objetos son vistos en silueta. Por ello, como criterios de calidad se usan el nivel y la uniformidad de luminancia de la superficie de calzada, así como el control de deslumbramiento. No obstante, muchos objetos sobre la calzada tienen alta reflectancia, y por ello no serán vistos en silueta sino por luz reflejada directamente. Además, en condiciones de tráfico congestionado, mucha parte de la visión de la superficie de la calzada puede ser obstruida por vehículos y así no se puede proporcionar un fondo para revelar objetos. Sin embargo, el modo de obtener un buen nivel y uniformidad de luminancia de la calzada con adecuado control de deslumbramiento ha sido ampliamente adoptado en recomendaciones nacionales e internacionales. La experiencia conseguida en el empleo de estos criterios durante un número de décadas indican que proporcionan una base satisfactoria para el diseño del alumbrado viario. Aunque los valores de los criterios prescritos se consiguieran originalmente como resultado de trabajos experimentales, han sido atemperados por experiencias durante este tiempo y las recomendaciones de este documento representan una buena práctica en la actualidad.

En algunos Países, se han usado métodos basados en conceptos de CIE 19.21 y 19.22-1981. En estas recomendaciones se usa la visibilidad como una medida y es calculada en términos de diferencia de luminancia real y de umbral, entre el objeto y la superficie de la calzada. Con la mayor disponibilidad y potencia de ordenadores, la aplicación de modelos de visibilidad ha llegado a ser practicable para el diseño rutinario para el alumbrado viario. Uno de tales métodos de visibilidad de pequeños objetos está descrito en este documento (apartado 7) y ha sido el objeto de numerosos ensayos y pruebas (Keck, 1987; Lecocq, 1991; Ménard, 1992).

5.2 Elección de la clase de alumbrado

Las recomendaciones sobre tipos de alumbrado están clasificadas de M1 a M5, que son seleccionadas conforme a la función de la vía pública, densidad de tráfico, complejidad del tráfico, separación del tráfico y la existencia de facilidades para el control del tráfico, tales como señales de tráfico. Ejemplos típicos están dados en la tabla 5.1. Las descripciones de la vía pública son amplias, de modo que puedan ser interpretadas acomodándolas a los requisitos individuales para las recomendaciones nacionales. Cuando se hace una selección deben considerarse todos los usuarios de la calzada incluyendo conductores de vehículos, motoristas, ciclistas y peatones.

ABLA 5.1 Clases de Alumbrado para diferentes tipos de vías públicas

DESCRIPCION DE VÍAS PÚBLICAS	CLASE ALUMBRADO
Carreteras de alta velocidad con carriles separados libres de intersecciones al mismo nivel y con accesos completamente controlados: autopistas, autovías. Densidad del tráfico y complejidad del trazado de la calzada (Nota 1). Alta Media Baja	 M1 M2 M3
Carreteras de alta velocidad, calzada con doble sentido de circulación. Control de tráfico (Nota 2) y separación (Nota 3) de diferente tipos de usuarios de carreteras (Nota 4). Pobre Bueno	 M1 M2
Vías urbanas de tráfico importante, carreteras radiales y de distribución a distritos Control de tráfico y separación de diferentes tipos de usuario. Pobre Bueno	 M2 M3
Carreteras secundarias de conexión, carreteras distribuidoras locales, vías de acceso principales residenciales, carreteras que proporcionan acceso directo a propiedades y conducen a conexiones de carreteras. Control de tráfico y separación de diferentes tipos de usuario. Pobre Bueno	 M4 M5

Nota 1: La complejidad del trazado de carreteras se refiere a la infraestructura, movimiento del tráfico y alrededores visuales.

Factores que deben considerarse son:

- Número de carriles, pendientes.
- Señales e indicadores.

Rampas de entrada y salida, vías de incorporación, rotondas, etc.. cuya presencia debe ser considerada, también como se ha recogido en el apartado 8, alumbrado para áreas conflictivas.

Nota 2: Control de Tráfico se refiere a la presencia de indicadores y señales y a la existencia de regulaciones.

Los métodos de control son:

- Semáforos, reglas prioritarias, regulación y señales prioritarias, señales de tráfico, señales de dirección y marcas en la calzada. Cuando están ausentes o no hay el control de tráfico, es considerado como pobre y viceversa.

Nota 3: Separación puede ser por medio de líneas trazadas para tal fin o por la restricción de uno de los tipos de tráfico. Puede considerarse el menor grado de iluminación como adecuado cuando exista separación.

Nota 4: Los diferentes tipos de usuarios de carreteras son, por ejemplo, vehículos de turismo, camiones, vehículos lentos, autobuses, bicicletas y peatones.

5.3 Variación temporal de la Clase de alumbrado conforme a la densidad de tráfico

Cuando se varía la Clase de alumbrado de una carretera para adaptarse a los cambios de densidad del tráfico durante la noche para conservación de la energía (por ejemplo, la Clase de alumbrado es reducida después de la medianoche), los cambios deben ser tales que satisfagan todos los requisitos de la Clase de alumbrado mayor o menor apropiada (es decir, si la luminancia media de la superficie de la carretera se reduce a la de una clase inferior, se satisfarán los criterios de uniformidad y de deslumbramiento de esa clase).

6. REQUISITOS PARA TRAFICO MOTORIZADO - CONCEPTO DE LUMINANCIA.

Los criterios de control son:

- Nivel y uniformidad de luminancia de los carriles de tráfico.
- Alumbrado del entorno o de los alrededores de la carretera
- Limitación del deslumbramiento, tanto molesto como perturbador.
- Guiado visual directo.

La descripción numérica de los tres primeros criterios y los valores recomendados para ellos, en distintas situaciones de tráfico, están dados en la tabla 6.1. No es posible actualmente cuantificar el guiado visual pero debe hacerse referencia al apartado 6.8 para aplicarlo en la práctica. Para consejos sobre aspectos de apariencia y ambientales, véase el apartado 10.

Los criterios de alumbrado empleados en la Tabla 6.1 son luminancia (L) media mantenida de la superficie de la calzada, uniformidad global (U_o) y uniformidad longitudinal (U_L), relación de alrededores (SR), e incremento de umbral (TI). A continuación se da una descripción detallada de estos términos. Estos valores son de aplicación a calzadas secas: el apartado. 6.7 da recomendaciones para calzadas húmedas o mojadas.

ABLA 6.1 Requisitos de alumbrado para trafico motorizado basado en luminancia (L) de la superficie de la calzada (NR cuando no se requiere ningún valor).

CLASE DE ALUMBRADO	CAMPO DE APLICACIÓN				
	TODAS LAS CALZADAS	TODAS LAS CALZADAS	TODAS LAS CALZADAS	CALZADAS SIN O CON POCAS INTERSECCIONES	CALZADAS CON ACERAS NO ILUMINADAS PARA CLASES P1 A P4 EN APTDO. 6.5
	L ($cd.m^{-2}$) MINIMA MANTENIDA > APTDO. 6.1	U_o MINIMA > APTDO. 6.2	$TI_{\%}$ MAXIMO INICIAL % APTDO. 6.3	U_l MINIMA > APTDO. 6.4	SR MINIMO APTDO. 6.5
M1	2.0	0.4	10	0.7	0.5
M2	1.5	0.4	10	0.7	0.5
M3	1.0	0.4	10	0.7	0.5
M4	0.75	0.4	10	NR	NR
M5	0.5	0.4	10	NR	NR

6.1 Luminancia media de la superficie de calzada L.

Este es el valor mínimo que ha de mantenerse a lo largo de la vida de la instalac Depende de la distribución luminosa de la luminaria, del flujo luminoso de las lámpa de la geometría de la instalación y de las propiedades de reflexión de la superficie c calzada. Son aceptables niveles mayores cuando pueden ser económicam justificados.

El cálculo y medida de la luminancia media de la superficie de la calzada debe realiz conforme con la CIE 30.02.1982.

Los valores calculados deben tener en cuenta los factores de mantenimiento d lámpara y de la luminaria. Los factores de mantenimiento de la luminaria varían acuerdo con los intervalos entre limpiezas, la magnitud de contaminación atmosféric la calidad de cierre hermético del alojamiento de la lámpara y en la luminaria. Sus val pueden ser establecidos por mediciones de campo. Los factores de mantenimiento flujo de lámpara varían según el tipo de lámpara y su potencia. Estos val normalmente se consiguen solicitándolos a los fabricantes de lámparas.

6.2 Uniformidad global de luminancia de calzada U_o.

Esta es la relación entre la luminancia mínima en un punto de la retícula y la luminar media de la superficie de la calzada (debe tomarse nota de que en los requisitos iluminación dados en el apéndice A para NIVEL DE VISIBILIDAD, se ha usado en su lu la relación de la luminancia mínima a la luminancia máxima) y es medida de acuerdo la CIE 90.02.1982. Su valor depende de los mismos factores que L. Este criterio importante, en lo que se refiere al control de la visibilidad mínima sobre la calzad también afecta al confort.

6.3 Incremento de umbral TI.

Esta es una medida de la pérdida de visibilidad causada por el deslumbramie perturbador procedente de las luminarias de alumbrado viario instaladas. La fórmul partir de la cual se calcula está basada sobre el incremento porcentual en la diferencia luminancia necesaria para hacer el objeto visible en presencia de deslumbramie cuando el objeto es justamente visible en la ausencia de deslumbramiento, es de cuando las luminarias están apantalladas de la vista del observador. El procedimie matemático está dado en CIE 31-1976, y el cálculo está hecho para una luminaria lim equipada con una lámpara que emite el flujo luminoso inicial.

El deslumbramiento perturbador resulta de la dispersión de la luz dentro del ojo, lo c reduce el contraste de la imagen sobre la retina. El efecto puede ser explicado por superposición de una luminancia de velo uniforme sobre la escena, la cual es cuantifica como la luminancia de velo equivalente. La magnitud de ésta depende de la iluminan sobre el ojo del conductor procedente de las luminarias y de los ángulos a los que se v Mientras el grado de deslumbramiento perturbador aumenta con la luminancia de v equivalente, disminuye en función de la luminancia media de calzada.

TI está calculado para las condiciones peores, que es con una luminaria limpia y el fl inicial de la lámpara.

6.4 **Uniformidad longitudinal de luminancia de la superficie de calzada U_l.**

Esta es la relación de la luminancia mínima a la luminancia máxima a lo largo de una línea o líneas paralelas al sentido de circulación de la carretera. Es calculada y medida de acuerdo con CIE 30.02.1982, y su valor depende de los mismos factores que la L.

Este es fundamentalmente un criterio relativo al confort y su propósito es impedir que el repetido diseño de altas y bajas luminancias sobre una línea de la calzada iluminada resulte demasiado pronunciado. Esto solamente se aplica a grandes secciones de calzada ininterrumpidas.

6.5 **Relación de entorno SR.**

Uno de los principales propósitos de iluminar vías públicas es crear una superficie de calzada brillante contra la cual los objetos puedan ser vistos. No obstante, las partes superiores de objetos altos en la calzada y los objetos situados hacia el lado de la calzada, particularmente en secciones curvas, son vistos contra los alrededores o entorno de la calzada. Así, la iluminación adecuada de los alrededores ayuda al conductor a percibir más del entorno y a hacer ajustes de la velocidad en el tiempo.

La función de la relación de entorno es para asegurar que la luz dirigida a los alrededores es suficiente para que los objetos sean revelados. La luz es también un beneficio para los peatones cuando hay presente una acera.

En situaciones en las que los alrededores están ya iluminados el uso de la relación de entorno es innecesario.

La relación de entorno es la iluminancia media en bandas, de 5 m. de ancho, o menos si el espacio no lo permite, que son adyacentes a los bordes de ambos lados de la calzada, a la iluminancia media en bandas adyacentes de la calzada de 5 m de ancho o de la mitad del ancho de la misma, el de menor magnitud en la calzada. Para calzadas de doble sentido de circulación, ambos carriles juntos son tratados como una sola calzada a menos que estén separados en más de 10 m.

6.6 **Deslumbramiento molesto.**

No se ha considerado totalmente satisfactorio ningún método para cuantificar el deslumbramiento molesto en los conductores en calzadas de tráfico. Antiguamente se usó G, Índice del Control del deslumbramiento (CIE 31-1976) descrito en el apéndice B, pero se detectaron anomalías. La evidencia de campo sugiere que las instalaciones diseñadas, dentro de los límites del incremento umbral recomendados en la Tabla 6.1 son generalmente aceptables en lo que se refiere al deslumbramiento molesto.

Los alrededores brillantes, tal como edificios iluminados, tienden a mitigar el deslumbramiento molesto, pero como la iluminación de los edificios es variable y puede ser apagada durante la noche, no es factible aceptar esto en el diseño de iluminación de vías públicas.

6.7 Condiciones de calzadas húmedas.

Cuando la superficie de la calzada está húmeda tiende a comportarse de modo más parecido a un reflector especular que a uno difuso. Las partes más brillantes de la calzada disminuyen de área y aumentan de luminancia, y lo contrario sucede para áreas más oscuras. El resultado es que la uniformidad de luminancias es severamente degradada y la visibilidad en una gran proporción de la calzada resulta afectada de modo adverso.

En Países en los que la calzada está húmeda durante una proporción de tiempo considerable de veces, debe seleccionarse una distribución de luz que minimice este efecto perjudicial. La CIE 47-1979, proporciona detalles para calcular U_o para condiciones húmedas. Además, debe prestarse consideración, siempre que sea posible, a la selección de materiales permeables para la superficie de la calzada, que pueden ser también beneficiosos.

U_o en condiciones húmedas debe ser mayor de 0'15 para la geometría, tabla de reflectancia W, y luminaria seleccionada. Además de esto, deben satisfacerse los criterios para la clase apropiada de iluminación en condiciones secas de la tabla 5.1.

6.8 Recomendaciones para el guiado visual directo.

No se ha considerado ningún método para cuantificar el guiado visual directo (véase apartado 4.7) pero hay ciertas consideraciones prácticas que son útiles.

A veces el diseño de luz directa desde las luminarias de alumbrado viario puede ser confuso. Esto puede evitarse en la etapa de diseño considerando el diseño en perspectiva, es decir, cómo aparecen la alineación y el posicionamiento de las luminarias para el usuario de la calzada.

El guiado visual directo puede ser mejorado cambiando a una fuente de luz de diferente color en cruces, glorietas, etc.. El cambio debe ser consistente en un área e intencionado.

7. REQUISITOS PARA TRAFICO MOTORIZADO-CONCEPTO DE NIVEL DE VISIBILIDAD.

La visibilidad de un objeto depende de varios factores:

- El contraste de la luminancia de la superficie del objeto con la luminancia del fondo.
- La adaptación relativa del ojo a ese objeto.
- La magnitud del deslumbramiento perturbador.
- La adaptación transitoria (reducción del contraste equivalente debido a la readaptación del fondo de una luminaria a otra) como resultado de la fijación del ojo.
- La complejidad visual del fondo y los movimientos dinámicos.
- El color, tamaño y forma del objeto.
- La edad y las características visuales del conductor.

Se ha intentado caracterizar estos factores numéricamente y combinarlos en una sola cifra que se puede utilizar como medición de la visibilidad. El modelo de visibilidad tratado en este documento se basa en la siguiente fórmula:

$$VL = \frac{\Delta L_{real}}{\Delta L_{umbral}}$$

donde:

VL es el nivel de visibilidad. No tiene dimensiones: es una proporción para indicar en qué medida el contraste del objeto está por encima del contraste del umbral.

ΔL_{real} es la diferencia real en luminancia entre el objeto y su fondo.

ΔL_{umbral} es la diferencia de luminancia necesaria entre un objeto de un determinado tamaño angular y su fondo, para que el objeto sea visible, es decir, en el umbral.

La primera ventaja reivindicada para usar el concepto del Nivel de Visibilidad es que permite la optimización del uso de la energía.

Visibilidad del Pequeño Objeto (STV)

La visibilidad del Pequeño Objeto (STV) en el nivel de visibilidad VL calculado según el modelo de visibilidad descrito en (Adrian, 1989). Para calcular el nivel de visibilidad, VL debe especificarse una tarea y un observador. Aunque las tareas visuales generales de la conducción se pueden definir de forma concisa y exacta, las tareas concretas de la conducción varían en gran medida y están en continuo cambio. El nivel de visibilidad VL de este documento esta basado en la detección de un "Pequeño Objeto"; que es un objeto cuadrado y plano de 0,18 m de lado con una reflectancia difusa del 20%. El objeto es perpendicular a la superficie de la calzada y siempre está situado a una distancia fija (83 m) por delante del observador, siendo la línea de visión del observador al objeto paralela a la línea central de la calzada. Este acuerdo mantiene constante tanto el tamaño del objeto como la geometría del objeto-observador. La altura del observador, su edad y la línea de visión del mismo al centro del objeto son también constantes (consúltese el Apéndice A para más detalles).

Si se selecciona una reflectancia de valor cero para el objeto, como caso especial, el lugar de la de la calzada donde tiene lugar la visibilidad mínima del objeto será aquel punto en el que la luminancia de la superficie de la carretera alcance su valor mínimo. Este principio proporcionó la base original del "Concepto de Luminancia" tratado en el apartado 4.7. Si se selecciona una reflectancia mayor que cero para el objeto caso general, el lugar de la calzada donde tendrá lugar la mínima visibilidad del objeto será donde el contraste entre la luminancia del objeto y su fondo tenga su valor mínimo. Los factores de control son:

- luminancias de partes de la calzada que proporcionan un fondo al objeto.
- luminancia de la cara del objeto vista por el observador
- adaptación visual del observador
- limitación del deslumbramiento, molesto y perturbador.
- guiado visual

Actualmente, se está intentando llegar a un acuerdo internacional sobre la elección de los parámetros para calcular la (STV), particularmente en lo que se refiere a la edad del observador, la forma del objeto, su reflectancia o margen de reflectancias, así como la parte de la superficie de la calzada que debe considerarse como fondo para el objeto. Asimismo, queda por decidir si la (STV) mínima sobre la superficie de la calzada es la métrica operativa, o si la media aritmética o la media ponderada resultan más relevantes. Se están realizando experimentos puntuales para resolver estos aspectos y para encontrar la relación entre la (STV) y los accidentes.

Hasta que exista más experiencia registrada de aplicación de (STV) en campo, no es posible realizar recomendaciones no cualificadas sobre su uso. No obstante, el uso de la (STV) se recomienda en la revisión del borrador de The American Standard Practice for Road Lighting (ANSI/IES, 1990) y se está trabajando firmemente para obtener experiencia en su uso. Debido a su potencial para ahorrar energía y costes, queda descrito en este documento para permitir que otros países lo adopten o exploren las posibilidades del método, si así lo desean. Los valores de diseño sugeridos aparecen en el Apéndice A.

ALUMBRADO DE ÁREAS CONFLICTIVAS

Las áreas conflictivas son aquéllas en las que las corrientes de vehículos se cortan entre sí o transcurren en áreas frecuentadas por peatones, ciclistas y otros usuarios viarios, o cuando la carretera existente está conectada a un tramo con geometría subestándar, tal como un reducido número de carriles o un carril o carretera con anchura reducida. Su existencia da como resultado un potencial aumentado para colisiones entre vehículos, entre vehículos y peatones, ciclistas u otros usuarios viarios o entre vehículos y objetos fijos.

El alumbrado debe revelar la existencia del área conflictiva, la posición del bordillo de la acera y las marcas de la calzada, las direcciones de la misma, la presencia de peatones, otros usuarios viarios y obstrucciones y el movimiento de los vehículos en proximidad al área conflictiva. Cuando, de lo contrario, no exista iluminación en la calzada que lleva a o abandona el área conflictiva, la iluminación, según se recomienda en las Tablas 8.1 y 8.2, debe instalarse en un tramo lo bastante grande para proporcionar aproximadamente 5 segundos de distancia de conducción a la velocidad de tráfico esperada.

Para áreas conflictivas, la luminancia es el criterio de diseño recomendado. Sin embargo cuando las distancias de visión sean cortas y otros factores impidan el uso de los criterios de luminancia, se puede utilizar la iluminancia en una parte del área conflictiva, o en todo el área si el criterio de luminancia no puede aplicarse a todo el área.

Cuando se utiliza la luminancia como criterio, la Clase del alumbrado en el área conflictiva debe ser un escalón más alto que la de la calzada o calzadas que llevan al área conflictiva (por ejemplo, M2 en lugar de M3). Esto no será posible cuando las carreteras de entrada se iluminen con la Clase M1. En este caso, el área conflictiva debe iluminarse también con la Clase M1.

Cuando se usa la iluminancia como criterio, la iluminancia de la superficie de la calzada en todo el área conflictiva no debe ser menor que la iluminancia proporcionada en cualquiera de las carreteras que se dirigen al área conflictiva. Este requisito se verá satisfecho siguiendo las recomendaciones de la Tabla 8.1. En la columna Clase de Alumbrado, la letra C indica Area conflictiva y el número corresponde a la Clase de Alumbrado, de la tabla 5.1, de la carretera más importante que se dirige hacia el área conflictiva (por ejemplo, si la carretera más importante que se dirige hacia el área conflictiva es M4, el área conflictiva debe iluminarse con C4 estándar, o en determinados casos indicados en la Tabla 8.2 con la siguiente categoría superior; es decir, C3. E es la iluminancia media sobre la superficie utilizada y U_o(E), la uniformidad de iluminancia, es la iluminancia mínima sobre la carretera dividida por E. Aquellas aceras que no estén iluminadas por separado de acuerdo con una de las Clases P1 y P4 de la tabla 9.2, deben iluminarse al menos con la mitad del nivel proporcionado a la calzada.

A menudo no resulta práctico usar *TI* para la cuantificación del deslumbramiento perturbador, porque los diseños no estándar usados en las áreas conflictivas dificultan su cálculo, y porque el punto de vista cambiante del conductor hace que la luminancia de adaptación sea incierta. En estas circunstancias, se recomienda restringir el deslumbramiento limitando la intensidad a 30 cd/klm a 80° de elevación y a 10 cd/klm a 90° en ángulos de azimut en los que las luminarias son vistas por el conductor; los ángulos de elevación se miden cuando las luminarias están montadas en la posición en la que se van a utilizar.

Tabla 8.1 Requisitos de alumbrado para áreas conflictivas

CLASE DE ALUMBRADO	(lx) sobre toda la superficie utilizada Mínima mantenida	U_o(E) Uniformidad de Iluminancia mínima
C0	50	0,40
C1	30	0,40
C2	20	0,40
C3	15	0,40
C4	10	0,40
C5	7,5	0,40

La Tabla 8.2 ofrece ejemplos de la aplicación de la Tabla 8.1 en áreas conflictivas típicas. En esta tabla, la letra que va entre paréntesis es el número de clase; de este modo, por ejemplo C(N) = M(N-1) significaría que la clase del área conflictiva es C2, si la carretera más importante que se dirige hacia el área en cuestión es M3.

bla 8.2 Ejemplos de aplicación de las Clases de Alumbrado en áreas conflictivas cuando la luminancia no es aplicable

REA CONFLICTIVA	ILUMINANCIA CLASE ALUMBRADO
asos inferiores	C(N) = M(N)
:onfluencias, desvíos, rampas, áreas on badenes, áreas con anchura de :arril restringida	C(N) = M(N-1)
'asos a nivel: Simples Complejos	 C(N) = M(N) C(N) = M(N-1)
Rotondas sin señales: :ompleja o grande :omplejidad media simple o pequeña	 C1 C2 C3
Areas de atascos: :ompleja o grande :omplejidad media)equeña o simple	 C1 C3 C5

ALUMBRADO DE VÍAS PÚBLICAS PEATONALES

La tarea visual y las necesidades de los peatones difieren de las de los conductores en muchos aspectos. La velocidad del movimiento es menor y los objetos que están próximos al peatón son más importantes que los que están distanciados. El diseño de la superficie y la textura de los objetos de la calzada y de la acera son importantes para el peatón, pero menos para el conductor, para el cual predomina la visión de la silueta. Estas diferencias indican que los criterios de alumbrado que satisface las necesidades del conductor, pueden no satisfacer las del peatón, y viceversa.

Las ventajas de un alumbrado de buena calidad en calles residenciales están resumidas en la publicación CIE 92-1992. Además de mejorar el nivel de amenidad general, un buen alumbrado disuade de cometer delitos contra la persona y la propiedad, facilita la detección del delito, e imparte un mayor sentido de seguridad en una vecindad. El alumbrado residencial se suele instalar o mejorar, por tanto, como medida contra el delito y está asumiendo una importancia creciente en este papel, particularmente en las áreas urbanas.

Estudio de delitos e iluminación

La mayoría de los estudios de delito e iluminación se han realizado midiendo los índices de delitos antes y después de mejorar el alumbrado, o entrevistando a los residentes locales para registrar su opinión sobre la eficacia de la mejora en el alumbrado. Estos estudios se

han registrado en Estados Unidos de Norteamérica (Tien, 1979), UK (Painter, 1989, 1990), Japón (Informe núm. 4 1989) y Francia (J-C Mariner, 1983). No todos ellos proporcionan datos que estén basados en un estudio profundo, pero tomados en su totalidad, sugieren que un buen alumbrado puede reducir el número de actos delictivos y de acoso. Un alumbrado nuevo o mejorado recientemente puede "desplazar" el delito a las áreas adyacentes. Esto se detectó en un estudio realizando en el Reino Unido (Lloyd and Wilson, 1989) pero el índice de actos delictivos global se redujo, lo que quedó confirmado en un estudio más reciente llevado a cabo por Schreuder (Lux Europa, 1993).

Estos estudios también indican que el miedo a estos actos delictivos, que puede ser considerado tan perjudicial como el propio delito, se ve reducido mediante un buen alumbrado. Este miedo tiene un efecto adverso en la moral de un vecindario e impide a los residentes salir de sus casas por la noche. No sólo esto ha aumentado la sensación de aislamiento de los residentes sino que también proporciona mayores oportunidades para los delincuentes, porque hay menos gente que les observe o les detenga.

2 Accidentes en vías públicas de zonas residenciales

CIE 93, 1992 indica que la previsión de alumbrado en autopistas y carreteras arteriales con estándares reconocidos reducirá el número y la gravedad de los accidentes nocturnos. Sin embargo, existe poca información sobre la contribución que el alumbrado puede hacer a la reducción de los accidentes en horas nocturnas en carreteras locales o residenciales. Los accidentes en los que los peatones se ven involucrados constituyen un alto porcentaje de todos los accidentes de carretera, especialmente durante las horas nocturnas y crepusculares. Muchos de ellos tienen lugar en estaciones de tren y en paradas de autobús. No obstante, un número significativo de accidentes por la tarde y noche suele tener lugar en zonas residenciales.

3 Criterios de calidad

El alumbrado de vías públicas debe permitir que los peatones disciernan los obstáculos u otros peligros en su trayecto y que sean conscientes de los movimientos de otros peatones amigables o de otro tipo, que puedan estar en estrecha proximidad. Por ello, el alumbrado tanto de las superficies horizontales como verticales, así como el control del deslumbramiento, son importantes.

9.3.1 Iluminación de superficies horizontales

Para asegurar que el peatón pueda moverse por las superficies de la calzada y de la acera con total seguridad, la iluminancia horizontal, E_H debe ser adecuada.

Se mide al nivel del suelo en términos de valores medios y mínimos, y se aplica a toda la superficie utilizada, que generalmente incluye las superficies de la calzada y de la acera.

9.3.2 Iluminación de superficies verticales

Una iluminación adecuada de las superficies verticales es una necesidad para el reconocimiento facial y para permitir anticiparse a un acto de agresión. La cuantificación de esta iluminación presenta una dificultad debido a la multiplicidad de planos en cada punto de medida que se tiene que han de tenerse en cuenta. Se ha intentado solventar este problema considerando la iluminancia en un semicilindro vertical infinitesimal

situado a la altura de la cabeza (1,5m). Esta medida, la iluminancia semicilíndrica, E_{sc}, se ha presentado en la publicación CIE 92-1992, como un anexo a la iluminancia horizontal, pero ha obtenido aún sólo una aceptación limitada puesto que presenta dificultades en su aplicación. Asimismo, para su medición, se requiere una especial adaptación para el montaje de la célula fotoeléctrica que se usa para medir la iluminancia en los planos. Su uso, por tanto, se recomienda sobre una base experimental, como se menciona en la introducción.

9.3.3 Control del deslumbramiento

El control del deslumbramiento molesto y perturbador no resulta tan crítico como para el conductor porque la velocidad de movimiento es bastante inferior, ofreciendo un tiempo de reacción mayor. No se ha llegado a ningún acuerdo en cuanto a un método de cuantificación del deslumbramiento a nivel internacional, pero existen actualmente varios métodos en uso sobre una base nacional. Detalles sobre estos métodos se ofrecen en el Apéndice C, y otros métodos adicionales aparecen en la publicación CIE 92-192. Además de lo anterior, es necesario considerar otros aspectos determinados del alumbrado. Generalmente, la luz por encima del plano horizontal deberá reducirse al mínimo, debido a que su despilfarro puede causar perjuicios al brillar a través de las ventanas de los dormitorios y contribuir al resplandor del cielo. Consúltese el apartado 10 para obtener detalles sobre la apariencia que necesita considerarse.

9.3.4 Elección de la fuente de luz

Deben evitarse las fuentes de luz monocromáticas para áreas en las que el riesgo al delito sea alto, que sean sensibles medioambientalmente o en las que predominen las actividades de los peatones.

9.4 Niveles de iluminación para tráfico peatonal

Existen siete clases de alumbrado, P1 a P7, que se enumeran en la Tabla 9.1. P1 se utiliza para las áreas de prestigio donde se requiere un alto nivel de iluminación para producir un ambiente atractivo. Las seis clases restantes se gradúan de acuerdo con el uso realizado por los peatones y con la necesidad de preservar el carácter del entorno. Las clases P5, P6 y P7 sólo se debe utilizar cuando el riesgo del delito sea insignificante. Donde sea probable que el riesgo de delito sea alto, se debe considerar la elección de una clase que sea un nivel o, en casos graves, dos niveles más alto que la clase que se elegiría en ausencia de riesgo de delitos (por ejemplo, P4 o P3 en lugar de P5). Estas recomendaciones también se aplican a aquellas calzadas que son utilizadas por ciclistas u otro tráfico no motorizado. La Tabla 9.2 ofrece las necesidades asociadas, que para las clases P1 a P6 se aplican a toda la superficie utilizada, es decir, la superficie de la acera, si hubiera, y la calzada. Para la clase P7, es esencial que las partes brillantes de la luminaria sean visibles desde la posición de la luminaria más próxima, y preferiblemente más allá, para proporcionar un guiado visual eficaz.

Tabla 9.1 Clases de alumbrado para diferentes tipos de calzada en áreas peatonales.

DESCRIPCION DE LA CALZADA	CLASE DE ALUMBRADO
Calzadas de alto prestigio	P1
Uso nocturno intenso por peatones o por ciclistas	P2
Uso nocturno moderado por ciclistas o por peatones	P3
Uso nocturno menor por ciclistas o por peatones únicamente asociados con propiedades adyacentes	P4
Uso nocturno menor por ciclistas o por peatones únicamente asociados con propiedades adyacentes Importante preservar el carácter arquitectónico del entorno.	P5
Uso nocturno muy reducido por ciclistas o por peatones únicamente asociados con propiedades adyacentes Importante preservar el carácter arquitectónico del entorno.	P6
Calzadas donde se requiere sólo la guía visual proporcionada por la luz directa de las luminarias	P7

Tabla 9.2 Necesidades de alumbrado para tráfico peatonal

CLASE DE ALUMBRADO	ILUMINANCIA HORIZONTAL (lux) en toda la superficie utilizada Mantenida	
	MEDIA Sub-apartado 9.3.1	MINIMA Sub-apartado 9.3.1
P1	20	7,5
P2	10	3
P3	7,5	1,5
P4	5	1
P5	3	0,6
P6	1,5	0,2
P7	No aplicable	No aplicable

ASPECTOS DE APARIENCIA Y MEDIOAMBIENTAL

El diseño y la colocación del mobiliario urbano pueden aportar una gran diferencia al aspecto de la calle, tanto de día como de noche.

Debe tenerse en consideración que el aspecto de la instalación de alumbrado durante el día está afectado por:

- la altura de las columnas de iluminación en relación a los edificios y árboles colindantes

- posición de las columnas de iluminación con respecto a las vistas del valor escénico: la obstrucción deberá reducirse todo lo que sea posible.

- diseño de los elementos de soporte

- complejidad de la disposición del alumbrado

- diseño de las luminarias

En áreas sensibles medioambientalmente, se preferirá el uso de una fuente de luz que permita la discriminación de colores.

Debe reducirse al mínimo la luz por encima del plano horizontal ya que contribuye a la contaminación luminosa, lo que aumenta el resplandor del cielo.

APENDICE A - NIVEL DE VISIBILIDAD

La Tabla A1 proporciona los requisitos de iluminación para las clases M de calzadas descrita en la tabla 5.1, cuando se emplea el Concepto de (STV) (Visibilidad del Pequeño Objeto).

Tabla A1 Requisitos de iluminación para tráfico motorizado basadas en el concepto de visibilidad.

CLASE DE ALUMBRADO	NIVEL DE VISIBILIDAD Mínimo Mantenido	L (cd.m^{-2}) Mínima Mantenida	L_{min}/l_{max} Mínima Mantenida	TI (%) Inicial
M1	7,5	1,0	0,2	10
M2	7,0	1,0	0,2	10
M3	6,0	0,7	0,2	10
M4	5,5	0,5	0,2	10
M5	5,0	0,5	0,2	10

Además del nivel de visibilidad, se especifican los siguientes criterios para que todos los aspectos del estándar de alumbrado queden controlados:

(a) Luminancia media de la superficie de la calzada, L, para disminuir el deslumbramiento procedente de los faros a un nivel aceptable. Véanse apartados 4.2 y 4.3.

(b) La diversidad de luminancia de la superficie de la calzada, para asegurar que la adaptación transitoria sea insignificante y que la apariencia de la calzada sea aceptable.

(c) El incremento del umbral para controlar el deslumbramiento perturbador. El efecto del deslumbramiento molesto está incluido en los cálculos del nivel de visibilidad.

(d) Relación con los alrededores (véase apartado 6.5)

(e) Guiado visual (véase apartado 4.7)

APENDICE B – ÍNDICE DE CONTROL DE DESLUMBRAMIENTO G

Esta es una escala de *G* (deslumbramiento) que va desde 1 a 9 y que indica la impresión subjetiva de la limitación del deslumbramiento molesto experimentado desde un conjunto de luminarias. 1 implica que la luminaria es "insoportable", 3 es "molesta", 5 "justo admisible", 7 es "satisfactoria" y 9 es "imperceptible". Se ha detectado que la impresión de deslumbramiento depende de varias cantidades fotométricas y geométricas y, con esta escala particular, se aplica la siguiente relación empírica (CIE 31-1976):

$$G = 13{,}84 - 3{,}31 \log I_{80} + 1{,}3(\log I_{80}/I_{88})^{0{,}5} - 0{,}08 \log I_{80}/I_{88} + 1{,}29 \log F + 0{,}97 L + 4{,}41 \log h' - 1{,}46 \log p$$

donde:

G es el Índice de Control de Deslumbramiento

I_{80} es la intensidad absoluta (cd) a un ángulo de 80° con la vertical descendente, en un plano vertical paralelo al eje de la calzada.

I_{80}/I_{88} es la relación de las intensidades luminosas a 80° y 88° con la vertical descendente, en un plano vertical paralelo al eje de la calzada.

F es el área iluminada proyectada ortogonalmente de la luminaria en una dirección de 76° con la vertical descendente, en un plano paralelo a la calzada.

L es la luminancia media de la superficie de la calzada ($cd.m^{-2}$)

h' es la distancia vertical (m) entre el nivel del ojo y la luminaria

p es el número de luminarias por kilómetro.

La fórmula para *G* es válida para los siguientes márgenes de valores:

$50 < I_{80} < 700$ (cd)
$1 < I_{80}/I_{88} < 50$
$0{,}007 < F < 0{,}4$ (m^2)
$0{,}3 < L < 7$ ($cd.m^{-2}$)
$5 < h' < 20$ (m)
$20 < p < 100$
número de filas de luminarias = 1 ó 2

APENDICE C - METODOS NACIONALES DE CONTROL DE DESLUMBRAMIENTO EN AREAS RESIDENCIALES

C1 METODO NORDICO

Evaluación del deslumbramiento molesto evaluado a partir de la fórmula del Grado de Deslumbramiento Molesto (DGR):

$$DGR = \text{valor máximo de } \frac{I}{\sqrt{A}}$$

donde:

I es la intensidad luminosa de la luminaria (cd)
A es el área de emisión de luz de la luminaria (m^2)

Todas las superficies están incluidas en el Area A en caso de que no existan partes de la fuente de luz visibles directamente o como imágenes rotas. L debe evaluarse para una luminaria limpia con una lámpara que emita un flujo luminoso inicial.

El máximo DGR se obtendrá para las direcciones entre 85° y 90° con la vertical descendente en cualquier ángulo del azimut.

Los valores límites del DGR son 500 y 1000 para alrededores oscuros y claros, respectivamente.

C2 METODO INGLES

Las luminarias que emitan 3,5 klm o más en el hemisferio inferior deben tener intensidades a 80° y 90° con la vertical descendente menores de 160 cd/klm y 80 cd/klm, respectivamente, en cualquier ángulo del azimut.

No existen restricciones de intensidad para las luminarias que emitan menos de 3,5 klm en el hemisferio inferior.

Cuando el alumbrado tenga un fin ornamental o decorativo, lo que normalmente se considera deslumbramiento se puede aceptar a veces como destellos. En estas circunstancias, no resulta apropiado aplicar las restricciones de deslumbramiento a la luminaria; su conveniencia necesita ser juzgada sobre una base subjetiva.

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