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International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

TECHNICAL REPORT

A Guide to Urban Lighting Masterplanning

CIE 234:2019

UDC:	628.971 628.974.8	Descriptor:	Exterior lighting Architectural use of light

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This Draft Technical Report has been prepared by Technical Committee (TC) 4-56 of CIE Division 4 "Transportation and Exterior Applications" (formerly TC 5-21 of Division 5 "Exterior Lighting and Other Applications") and has been approved by the Board of Administration and by Division 4 of the Commission Internationale de l'Eclairage. The document reports on current knowledge and experience within the specific field of light and lighting described, and is intended to be used by the CIE membership and other interested parties. It should be noted, however, that the status of this document is advisory and not mandatory.

Ce projet de rapport technique a été élaboré par le Comité Technique (TC) 4-56 de la CIE Division 4 "Transport et autres applications" (autrefois TC 5-21 de la Division 5 "Eclairage extérieur et autres applications") et a été approuvé par le Bureau et Division 4 de la Commission Internationale de l'Eclairage. Le document expose les connaissances et l'expérience actuelles dans le domaine particulier de la lumière et de l'éclairage décrit ici. Il est destiné à être utilisé par les membres de la CIE et par tous les intéressés. Il faut cependant noter que ce document est indicatif et non obligatoire.

Dieser Entwurf eines Technischen Berichts ist vom Technischen Komitee (TC) 4-56 der CIE Division 4 "Transport- und Außenanwendungen" (ehemals TC 5-26 der Division 5 "Außenbeleuchtung und andere Lichtanwendungen") ausgearbeitet und vom Vorstand sowie Division 4 der Commission Internationale de l'Eclairage gebilligt worden. Das Dokument berichtet über den derzeitigen Stand des Wissens und Erfahrung in dem behandelten Gebiet von Licht und Beleuchtung; es ist zur Verwendung durch CIE-Mitglieder und durch andere Interessierte bestimmt. Es sollte jedoch beachtet werden, dass das Dokument eine Empfehlung und keine Vorschrift ist.

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The following members of TC 4-56 (formerly TC 5-21) “A Guide to Urban Lighting Masterplanning“ took part in the preparation of this Technical Report. The committee comes under Division 4 "Transportation and Exterior Applications" (formerly Division 5 “Exterior and Other Lighting Applications”).

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A GUIDE TO URBAN LIGHTING MASTERPLANNING

Summary

The purpose of this publication is to provide guidance about the objectives and underlying principles relating to the lighting aspects of the urban nightscape. It deals with the visual, organizational, environmental, and technical elements of these aspects of urban planning.

This guide identifies the lighting planning criteria that should be considered when initiatives are being taken in relation to new or existing lighting in urban areas or newly planned conurbations. Guidance is provided to both the functional and expressive aspects of lighting.

This publication is intended to support those decision makers who are required to initiate, promote, and manage the night-time image of their city and who require a masterplan to provide a sound basis for long term lighting developments.

GUIDE DE LA PLANIFICATION DE L'ECLAIRAGE URBAINE

Résumé

Le présent document vise à servir de guide sur les objectifs et les principes sous-jacents de l'éclairage dans la scène urbaine nocturne. Il aborde les dimensions visuelles, organisationnelles, environnementales et techniques de l'urbanisme lumière.

Ce guide identifie les critères de conception de l'éclairage qu'il faut prendre en compte lors de la mise en place ou du renouvellement d'installations d'éclairage dans des milieux urbains existants ou dans des agglomérations planifiées. Il propose des recommandations tant pour l'éclairage fonctionnel que pour l'éclairage de mise en valeur.

Cette publication est dédiée aux décideurs qui ont la charge d'initier, de promouvoir et de gérer l'image nocturne de leur ville, et qui ont besoin d'un schéma directeur de l'éclairage pour prévoir son développement à long terme.

EIN LEITFADEN FÜR DIE ERSTELLUNG EINES MASTERPLANS FÜR BELEUCHTUNG

Zusammenfassung

Diese Publikation soll als Leitfaden hinsichtlich der Zielsetzung und der ihnen zugrunde liegenden Prinzipien für die nächtliche Stadtbeleuchtung dienen. Es werden die visuellen, organisatorischen, umweltbezogenen und technischen Elemente dieses Aspekts der Stadtplanung behandelt.

In diesem Leitfaden werden die Lichtplanungskriterien beschrieben, die berücksichtigt werden sollten, wenn Initiativen für neue oder existierende Beleuchtungsanlagen im städtischen Umfeld oder in neu geplanten Ballungsräumen ergriffen werden. Es werden Anleitungen in Hinsicht sowohl auf funktionelle als auch gestalterische Aspekte gegeben.

Die Publikation soll solchen Entscheidungsträgern als Unterstützung dienen, deren Aufgabe es ist, das nächtliche Erscheinungsbild ihrer Stadt zu initiieren, promoten und managen, und die einen Masterplan benötigen, um eine geeignete Basis für langfristige Beleuchtungsentwicklungen zur Verfügung stellen zu können.

1 Introduction

A well-lit city maintains a balance between the essential, functional, aspects such as road and street lighting and the elective aspects such as the lighting of buildings, infrastructure and landscapes. Additionally, the experienced lighting designer will seek opportunities to combine the functional with the elective, by providing essential lighting in an innovative way.

The manner in which a city is lit not only reveals its physical nature but also impacts the use of the city during night time. It also determines its image at night. A city nightscape which is predominated by purely functional lighting, such as that which must be provided for the safe movement of vehicles and pedestrians, the outdoor activities of city users in general (inhabitants, working people, tourists), or for the securing of property, will lack the visual qualities which provide for human attraction and delight. In this regard, there is a distinction between functional illumination and the visual expression, which well-designed, and comprehensively planned, lighting can contribute.

It is not easy to plan the urban nightscape in a holistic manner. This is because lighting is provided and controlled by numerous agencies. These range from the local government highways lighting department to the individual building owner who wishes to advertise his business through the external lighting of a corporate building or, perhaps only, a modest shop frontage. Additionally, the levels of lighting skill and experience that determine the night-time appearance of a city vary greatly. Firstly, this is due to cultural aspects, which are part of the city identity. Secondly, this variation ranges from the considered work of a specialized lighting designer, or that of an architect, to the activities of an electrical contractor who, by misapplying a security floodlight, creates a source of glare that negates an otherwise carefully balanced image of a precinct or individual building, and may even be contrary to safety.

The primary objective of a lighting masterplan is to identify all forms of lighting that contribute to the urban nightscape and to ensure that these are provided and operated in a manner which creates a balanced overall ambience with respect to the users' activities and energetic/environmental aspects. In order to achieve this, consideration must be given to not only the visual objectives but also to the legislative, managerial, and economic aspects. Since lighting is also a major, and visually obvious, consumer of energy and a potential source of light pollution, a lighting masterplan should provide clear guidance on achieving an optimum balance between energy consumption and the benefits of having an attractively lit city. The principal approach of main subjects is seen in Figure 1.

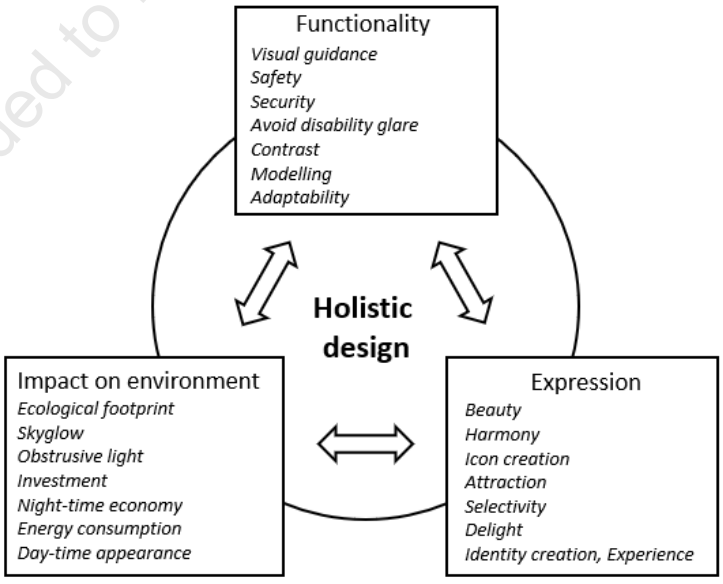


Figure 1 — Holistic design of a lighting masterplan

A further aspect of planned urban lighting relates to the night-time economy of a city. The relationship between a city that has invested in high quality lighting and its ability to attract and retain evening visitors is currently based on largely anecdotal evidence. However, limited economic studies suggest that investments into lighting can, or do, yield returns in terms of increased visitor numbers and per capita spend.

Finally, it is important to remember that all the elements of functionality, expression and environmental issues may vary with time. This holds true not only through the hours of the night, but also through the seasons of the year. The consideration of such matters is a key aspect to optimize the masterplan to fit at best its various aims.

1.1 Scope

The scope of a lighting masterplan is necessarily wide if it is to achieve its objectives and is to become a useful, long term, working document. A typical scope of work will include:

- A detailed analysis of the existing subject area or, in the case of a new conurbation, analysis of the planned layout and composition of the area. Such analysis requires in-depth survey work, macro and micro view analysis, photography, identification of distinctive precincts by built character or function, requirements of the various users, existing lighting conditions, ownerships of key buildings and structures and potential future developments, which may materially change views and vistas. Through this process it is important that the lighting planner becomes fully conversant with the ‘feel’ of the city, its morphology, its visual characteristics, and its life.
- A comprehensive consultation programme with all public and private sector stakeholders. This is an important element of a successful planning exercise and should be an early action item. The following note on ‘Consultation Groups’ summarizes the stakeholders who are normally concerned with lighting developments. The objective should be to ensure that the consultation is all embracing and that no disaffected party should be created. The role and involvement of the print, broadcast and media-internet should not be underestimated in gaining general public understanding and support for a civic lighting programme. Sometimes, the contribution of a sociologist can also improve communication with local individuals and associations and bring up further ideas for discussion (Chain, 2006).
- A close collaboration with the city’s highway lighting authority. Since, in most cities, road and street lighting comprises the core of public lighting, it forms a major proportion of the overall lighting. Accordingly, the quality and visual dominance of such lighting is a primary element in a lighting masterplan and close consideration requires its integration into the wider urban nightscape.
- Identifying national, regional and local lighting related legislation, mandatory codes, energy criteria and environmental guidelines.
- Establishing a successful relationship with the city’s political representatives to ensure that lighting development is well supported at community levels and within the various local government departments. Ideally, the consultant will be provided with one point of contact within the client organization; this may be an individual or a small committee formed to steer the project.
- Establishing a set of foundational lighting policies that can be presented to local government for adoption as extended planning legislation or an alternative regulatory system.
- Guiding the client in establishing a mechanism that will ensure the successful delivery of the lighting masterplanning objectives. This might include setting up, or extending, a city lighting management structure, and engaging of suitable experience and skill to implement and secure the long-term delivery of the lighting developments and their maintenance. Additionally, the client may require advice on innovative ways of securing the necessary funding for the capital and operational costs of lighting within the public and private sectors.

1.2 Consultation groups

The following is a summary of organizations that typify those that will have an interest in lighting development. Such organizations will vary in differing parts of the world but the principle should be to ensure the support and engagement of any agency, group, or individual who has the ability to encourage, and participate in, the development and implementation of improved lighting. Equally, it is important to pre-empt objections by ensuring that the views and involvement of all stakeholders have been secured.

At a minimum, the following organizations should be considered as potential advocates for a lighting development programme and, where appropriate, should be invited to support and participate in the programme. It should be noted that the lighting planner will be dealing with a different situation if he or she is responding to a lighting initiative already taken by a city government, as opposed to a situation in which a lighting improvement programme is being initiated by the lighting planner or by a non-governmental third party such as a local amenity improvement committee. In the first case, the fact that a city government has initiated the programme will facilitate support in an efficient manner, whilst in the second case the lighting planner will have to spend considerable time securing the correct level of support from the various administrations.

1.2.1 National government

Although lighting development for a particular city will, largely, be the responsibility of local government, it is possible that support for a lighting programme may also derive from national or federal government, through ministries such as:

- Ministry of Culture and Arts,
- Ministry of Tourism,
- Ministry of Environment,
- Ministry of Energy,
- Ministry of Transport,
- Ministry of Aviation,
- Ministry of Health.

1.2.2 Local government

Local or regional government structures vary widely throughout the world; consideration should be given to the involvement of:

- metropolitan government,
- local or regional government,
- city council(s)[1],
- local municipal councils.

1.2.3 Local government departments

Within levels of local government, the following are typical of the departments or agencies that will require to be engaged in, and contribute to, the lighting planning programme:

[1] It should be noted that the administration of major cities can vary from a unitary council structure to multiple councils. This has a potential influence on lighting planning and the fact that council boundaries may not align with the visual boundaries that are appropriate to a unified night-time presentation of a city.

- mayor or chief executive's office,
- planning and city development,
- roads and traffic planning,
- road and street lighting (some part of this may also require the involvement of the road and major highway lighting departments at national or state government level),
- architecture and design,
- parks and landscape design and operation,
- sport department,
- educational institutions,
- public transport,
- public works and maintenance,
- economic planning,
- heritage conservation,
- local tourism development,
- police,
- port authority – where a city has a waterfront condition.

1.2.4 Non-governmental organizations

People have wide-ranging interests in their environment and its well-being. They can be either residents, workers or visitors. The subject of lighting can raise a surprising degree of concern and a desire to have a voice in how lighting is to be used in different parts of the city. Because local government is frequently informed by groups such as are shown below, the lighting planner should engage these, and others, in consultation:

- astronomy societies,
- chambers of commerce and other business associations,
- women's interest groups,
- historical and heritage groups,
- property owners' groups,
- environmental action groups
- civic interest groups.

1.2.5 Building ownership

A major element of any lighting planning programme deals with the need to selectively light the city's buildings. In turn, this implies the cooperation of the owners of privately held buildings and the custodians of public buildings or structures, which are normally the city, regional or national governments.

When the lighting plan develops clear identification of the buildings to be lit, it will become important to establish contact with the relevant owners to gain their cooperation in the lighting programme. In the case of public buildings, this is normally not difficult, particularly if the lighting planner is engaged by the city council. In the case of privately owned buildings, the situation can become more complex because many larger commercial buildings are owned by property trusts, financial institutions or multiple owners of individual freeholds within the building. In such cases, it is best for the lighting planner to discuss the need to include the building within the lighting programme with the property manager or agency that represents the ownership.

1.2.6 Professional institutes or societies

Institutes, societies or associations may provide added profile and support to a lighting development programme, at local or national level:

- architects,
- urban planning and design professionals,
- landscape architects,
- sociologists,
- electrical and electronic engineering,
- IT engineering,
- energy engineering,
- environmental engineering,
- building services engineering,
- lighting and illumination engineering,
- transport engineering,
- civil engineering.

It should be noted that, in several countries, considerable lighting knowledge and experience reside in university departments such as the urban planning or architecture faculties. There are circumstances where this resource can play an important part in initiating and preparing a lighting masterplan.

1.2.7 Private companies

Although the implementation of a lighting masterplan is subsequent to the development of the plan itself, the interest and support of the lighting industry during the assembly and promotional stages of the masterplanning work can be of value. Local lighting manufacturing or distribution companies are frequently aware of practical lighting issues, restrictions and history, which the lighting planner will require to take into account. Since the local lighting industry will benefit from the eventual implementation of the masterplan, it is clear that it will provide ready support for the planning programme.

1.3 Who should initiate and prepare a lighting masterplan?

Lighting masterplans are frequently initiated by lighting designers or planners who have identified an opportunity for a substantially improved night-time presentation of a given city, or specific precinct within a city. Alternatively, a city administration may have been persuaded by its architectural or urban planning department that the subject of lighting needs to be considered as a specialized piece of work. On occasion, and in a larger city, the city lighting department may initiate a lighting masterplan as an internal exercise but, possibly, with the collaboration of an external specialist.

In any of these scenarios, it will be of fundamental importance to gain the support of local politicians. This can be achieved in the form of inspirational leadership from the mayor, an individual politician, a small group of politicians or, perhaps, the city's chief executive. Failure to secure political support and momentum will result in a lighting masterplan that achieves little or no implementation. Additionally, political support can assist immeasurably in the promotion of the plan during its formative stages and in gaining the level of public exposure it requires to secure cooperation from the city's private sector.

The motive for improving the night-time image of a city is frequently a blend of civic pride, anticipated economic benefit, or a response to a particular event such as the hosting of the Olympic Games or the bestowing of a title such as 'City of Culture'.

Whilst opinions and directives from the foregoing Consultation Groups will provide a firm foundation for much of the lighting planning work, it is unlikely that any one member of such groups will have the overall experience and awareness to be able to draw together all the necessary considerations into one cogent masterplan. This raises the question as to who is best placed to undertake this complex exercise.

It is likely that the solution lies in a team approach with one member of the team taking on the lead consultant role. It is almost always the case that the team should include a lighting design specialist and an architect who knows the city well. These two form the foundation of the team, which should also be able to draw on input from a wider group of specialists, including an urban planner and an economic consultant with particular experience of the night-time economy of urban areas.

Since the lighting masterplan work is, in the final analysis, a lighting work, it is preferable that the lighting design specialist should retain the lead consultant role and responsibility for the production of the final plan. Such a specialist should have direct personal experience in the design of exterior lighting across a wide range of applications. The specialist will be required to play the role of master designer, engineer, coordinator, interviewer, promoter, and editor. He or she will require to be adept in handling politicians, committees, public hearings, community and media, relations. There will be a requirement to provide knowledgeable inspiration, innovative thinking, and pragmatism. An urban lighting master-planner holds a great deal of responsibility for the future shaping and presentation of the city at night.

1.4 Beneficiaries

In the broadest sense, everybody benefits from an improved presentation of the urban nightscape and thereby from the creative and correct use of lighting as well as the existence of a successful lighting masterplan. The groups mentioned below are by no means independent of one another:

- residents,
- visitors,
- tourists,
- building owners,
- social and cultural institutions,
- retailers and service organizations,
- employers,
- politicians,
- environmentalists,
- astronomers.

Additionally, professionals benefit from the development of urban lighting. This includes the initiators of a masterplan project such as lighting designers, architects, and urban planners. Equally, there is benefit to those responsible for the realization of individual lighting projects such as manufacturers, installers and equipment distributors or wholesalers.

2 Concepts, definitions and methodology

Light is one of the most important elements within the physical environment and is the primary source necessary for all visual perception. During the day, the city is lit basically by the sun. This natural light, constantly changing in intensity and colour, gives the physical world its shape and form. However, when darkness falls, the view changes. The structure of objects disappears and shapes became difficult to discern. Under these conditions, the opportunities afforded by artificial lighting become apparent. The primary purpose of urban lighting is the provision of sufficient illumination to perceive the environment and to facilitate orientation, safety and security. This aspect of urban lighting is related to utility lighting such as roads,

squares, open spaces, airports, bus stations, car parks etc. The further purpose of lighting is to enhance the urban nightscape by emphasizing its aesthetic values, such as its architecture and cultural heritage, (including fountains and sculptures for example), plus natural vegetation and landscape.

The objective of masterplanning the urban nightscape is to integrate all these aspects in order that they visually complement each other rather than distract from each other, by taking into account not only the basic functional lighting, but also the aesthetic and emotional aspects of lighting design. Masterplanning can relate to the lighting of a complete city or selected urban elements, such as an important functional area or a part of the city e.g. a historical centre or a redeveloped industrial zone. A true lighting masterplan is not an isolated affair. Functional and architectural lighting must be integrated in one overall plan for a given area. Besides the visual performance in operating a task (driving, walking, playing, reading, etc.), the lighting requirement for all users of the city has much to do with emotion. This means that a successful urban nightscape can only be designed if the emotional effects of lighting are fully understood and predicted. (Serefhanoglu Sozen et al.,1995, Serefhanoglu Sozen et al., 2005; van Bommel, 2005)

2.1 Lighting masterplanning at national and regional levels

At a national level urban lighting planning is important since a substantial proportion of electrical energy is used for lighting. Additionally, the night-time image of a nation's major cities can be varied and characterized by different lighting design approaches at macro level.

From a lighting perspective, it is necessary to determine which city or cities are important in the national or regional context. In determining this, the following criteria should be considered:

- Status - is it a national or regional capital city?
- Urban identity - is it a historic or modern city?
- Tourism - does the city have natural attributes such as a coastline or access to nature?
- Commerce - is the city known for its commercial and economic activity including trade fairs or shows?
- Arts - is the city recognized as a seat of education with emphasis on culture and the arts?

It is important to consider those cities that possess significant potential. For example, over the years, Paris, Lyon, Glasgow and many other cities or city parts have been illuminated in accordance with a lighting masterplan and successfully presented to the city users. Similar questions are raised on a more local scale when an area of a city only is considered in the masterplan.

2.2 Masterplanning for urban lighting

In general, masterplans not only have an important national role but also are valuable to cities for many reasons such as ensuring their attractiveness and preparing for the future needs of their citizens. For example, traffic masterplans often are a key element in long term urban planning, as are infrastructure masterplans (for sewage, clean water, electricity etc.). Lighting masterplans are of equal value and importance.

Lighting is strongly related to the electrical distribution infrastructure of the city, which was normally originated to only provide power for utility lighting, but now has to also provide for architectural lighting. A comprehensive consideration of urban lighting can therefore be defined in two groups as specified in Figure 2:

- utility (functional) lighting,
- architectural lighting.

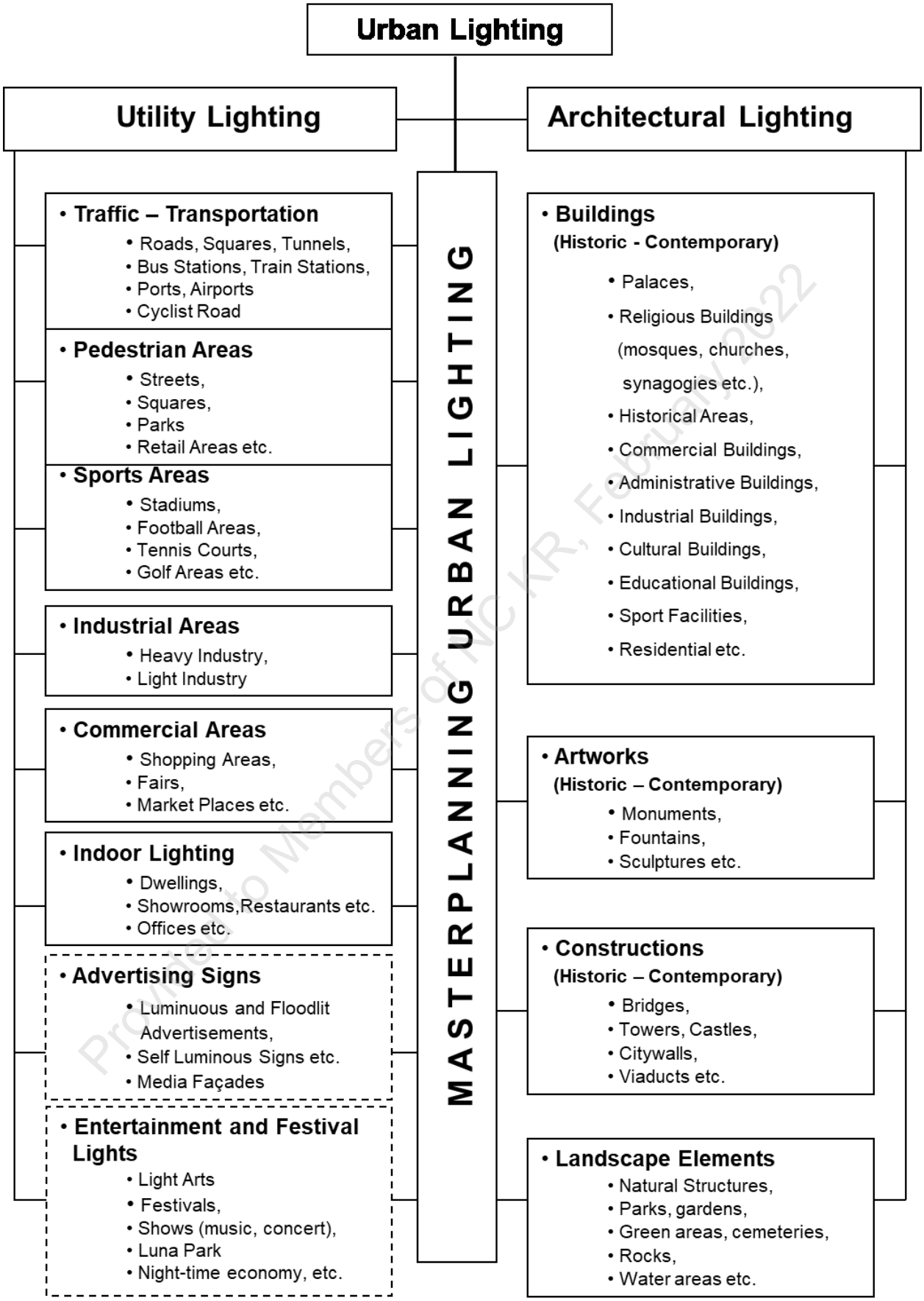


Figure 2 — Subjects of urban lighting (Serefhanoglu Sozen et al., 2005)

2.2.1 Utility lighting

The essential, or purely functional, lighting of a city is primarily a technical subject. However, this essential lighting should always be in harmony with its surroundings in order to reflect the nature of the city and support its overall visual and social character (see CIE 115 (CIE, 2010)).

Functional lighting comprises elements such as:

- roads, streets, cycle paths,
- squares,
- playgrounds, parks,
- waterside areas (urban river or ocean coast),
- industrial areas,
- sports areas,
- rail and port installations.

These necessary forms of lighting require as much consideration in the preparation of a lighting masterplan as any other type of lighting. This is because, if incorrectly designed, many of these lighting applications can generate sources of glare and significant levels of night sky light pollution. Additionally, they can seriously disrupt any attempt to create an overall night-time image of city which is visually balanced.

A further element of lighting that has become necessary in a contemporary city is that of signage and advertising. This represents a further consideration that the lighting planner must factor into the development of the lighting masterplan. Many city centres are predominated by illuminated signage and advertising which, by their very nature, seek to be as visually prominent as possible. Consideration must therefore be given to limiting the luminance of such lighting in order to create a balance with all other forms of lighting within the area under consideration.

Although the internal lighting of buildings, particularly commercial buildings, is not conventionally considered to be an aspect of urban lighting planning, it should be borne in mind that many major high rise buildings are designed to be substantially translucent in terms of the glass with which they are constructed. The overall contribution that the internal lighting of such buildings makes to the nightscape is therefore considerable, particularly when high-rise buildings are closely grouped in business districts, which forms a key visual element of the city. Although the lighting planner is unlikely to be able to influence the quality and quantity of interior lighting, it is important that this be considered and that the planning of the external lighting surrounding such buildings takes into account the view of the internal lighting.

2.2.2 Architectural lighting

Lighting masterplanning involves consideration of the elements which create the three-dimensional 'nightscape'; this includes architectural form, massing, landscape and the visual relationships between these. This is the basis of architectural urban lighting.

The lighting of elements such as public buildings, civil engineering works, natural sites, public works of art and parklands, can greatly help to express the functional, historical, architectural, social and aesthetic significance of a given area at night. Such lighting will include that of:

- buildings of historical heritage (palaces, castles, mosques, churches etc.);
- buildings representing institutions as identification marks (city halls, ministries, tribunals, operas, etc.);

- contemporary buildings (commercial, industrial, administrative, cultural, educational.);
- structures (bridges, towers, viaducts etc.);
- artworks (monuments, statues, fountains, sculptures, pavilions etc.);
- landscape architecture;
- natural structures;
- natural or manmade sites such as parks, gardens, green areas, trees etc., singularly or as a part of other urban elements;
- pedestrian areas (pedestrian zones, roads, squares and retail areas, playgrounds).

2.2.3 Masterplanning the urban nightscape

Specific benefits which arise from a planned approach to the urban nightscape include:

- amenity and safety to persons and properties in urban locations at night;
- emphasis to the structure and identity of specific precincts and improvement of their image at night;
- increased attractiveness of the urban environment at night to residents and investors, through well integrated essential and architectural lighting;
- an enjoyable urban environment in the evenings, with enhanced entertainment, amusement and recreation facilities after sunset, providing an enriched overall quality of urban life through a well-lit environment. It is evident that urban lighting has a direct impact on night-time activity; thus the choice of the lighting patterns will modify the use of a space (Chain, 2006; Mosser, 2008).

A town or city should reflect the cultural life of a community. In many senses people are the cast of a play and the city is the stage upon which they perform. Accordingly, communities need to be consulted about the lighting of their stage or environment.

Well-planned lighting is essential to satisfy functional, economic, social, and subjective needs; it results in the attraction of visitors and the reassurance of citizens. It can create and encourage:

- safety,
- orientation,
- spectacle,
- civic promotion,
- security,
- ambience,
- social interaction,
- identity and enterprise,
- experience of a space,
- pride for a neighbourhood or for citizens in general.

It can take the form of:

- amenity lighting for safe movement of pedestrians, shoppers and motorists by making obstacles (steps, ramps and the like) visible to avoid injury;
- improved lighting which creates a sense of security, a feeling of well-being for residents and investors and a reduction in crime and the fear of crime;
- lighting of landmarks and main traffic arteries to increase visual guidance throughout the city and to facilitate perception and orientation on an urban scale;

- lighting to emphasize the character or identity of the overall city or an individual precinct;
- lighting to enhance or emphasize selected natural, architectural, heritage, or colourful features within the environment;
- effective and stimulating lighting can create an impressive and a dignified image which can be an attraction to visitors and the business world; in this respect lighting can be an effective form of civic advertising or the 'branding' of the city;
- lighting which can reveal the beauty of a night-time scene and create new interpretations or visual relationships compared with those experienced during daytime;
- lighting which establishes visual landmarks and icons that provide orientation for visitors and reassurance for residents;
- lighting which provides an image that is welcoming and interesting to visitors;
- lighting which creates atmosphere, and fosters social interaction;
- light art, interaction, interactivity.

3 Relationship between urban planning and lighting

Urban design is important because it addresses the usage, operability and image of cities. A city that benefits from good urban planning is also likely to benefit from well-planned lighting, in the form of a lighting masterplan which should be considered an essential part of the wider urban plan.

A substantial element of urban planning relates to the provision of green and open spaces within a city – parks, squares, plazas and boulevards. These have been referred to as the 'lungs' of a city. It is in these spaces that lighting can provide not only appropriate levels of illumination but also form part of the urban 'furniture' by day and by night. This can be through both the physical hardware that is used to provide the lighting such as columns, bollards and luminaires as well as the visual appearance of the distributed light in terms of its graphic pattern at ground level and on vertical surfaces. In more literal terms there are also opportunities to provide 'luminous furniture' such as self-illuminated exterior seating and shelters.

Cities are recognized by their symbolic assets. These can be specific buildings such as the Parthenon in Athens, the White House in Washington or the Opera House in Sydney. They can also be structures such as the Eiffel Tower in Paris, the Statue of Liberty in New York or the Golden Gate Bridge in San Francisco. Each of these imparts an indisputably unique, and well-established, identity to the city in which it is located. In many senses the quality of the lit nightscape can become a further symbolic asset. This is exemplified by the night-time experience of the city of Lyon in France where the observer can be in no doubt about the image which lighting has imparted to that city. The same might be said of those areas of Shanghai that front on to its major river, Pudong and the Bund. Likewise, the night-time Manhattan, viewed from across the river Hudson, has been consciously shaped into a collective luminous identity. Few would dispute the value of the symbolism created by such lighting.

Every city requires continuous renewal, including the conservation of the best of its existing aspects. Urban planning is partially about developing new urban symbolism and identity. In turn, lighting, or the city's nightscape, is a valuable part of such identity. To this extent, urban planning and lighting planning are interwoven elements in the creation of a city's personality, both by day and by night.

It should be noted that, in the same manner that urban planning within a large city is an ongoing process, lighting planning should not be considered as an exercise that occurs only once, or in isolation. It is important that as each element of urban renewal and development is planned, a lighting planning component be included. This should relate to previous lighting

planning and apply established principles in order to maintain quality, whilst also allowing for the specific visual needs of the new areas of development.

4 Masterplan framework

A lighting masterplan is an important contribution to the creation of the life and use of a city's night-time environment and the success of its economy. The co-ordinator of the masterplan should develop a vision for the overall scope and purpose of the plan.

The masterplan should be considered as a framework within which the various lighting elements must fit. Individual and uncoordinated initiatives can be counterproductive in achieving this objective and should therefore be discouraged. As a starting point it can be helpful to carry out an analysis which provides a concept of scale, such as the views of the total city, districts and individual precincts. Such an analysis should examine individual elements of the city's built form, how these co-relate and to what degree they should be characterized as individual elements when viewed at night. This is the work that determines the foundational policies of the masterplan. (Hollands & Sprengers, 1994; Serefhanoglu Sozen et al., 1995; Serefhanoglu Sozen et al., 2005)

The work stages of a lighting masterplan are shown in Figure 3.

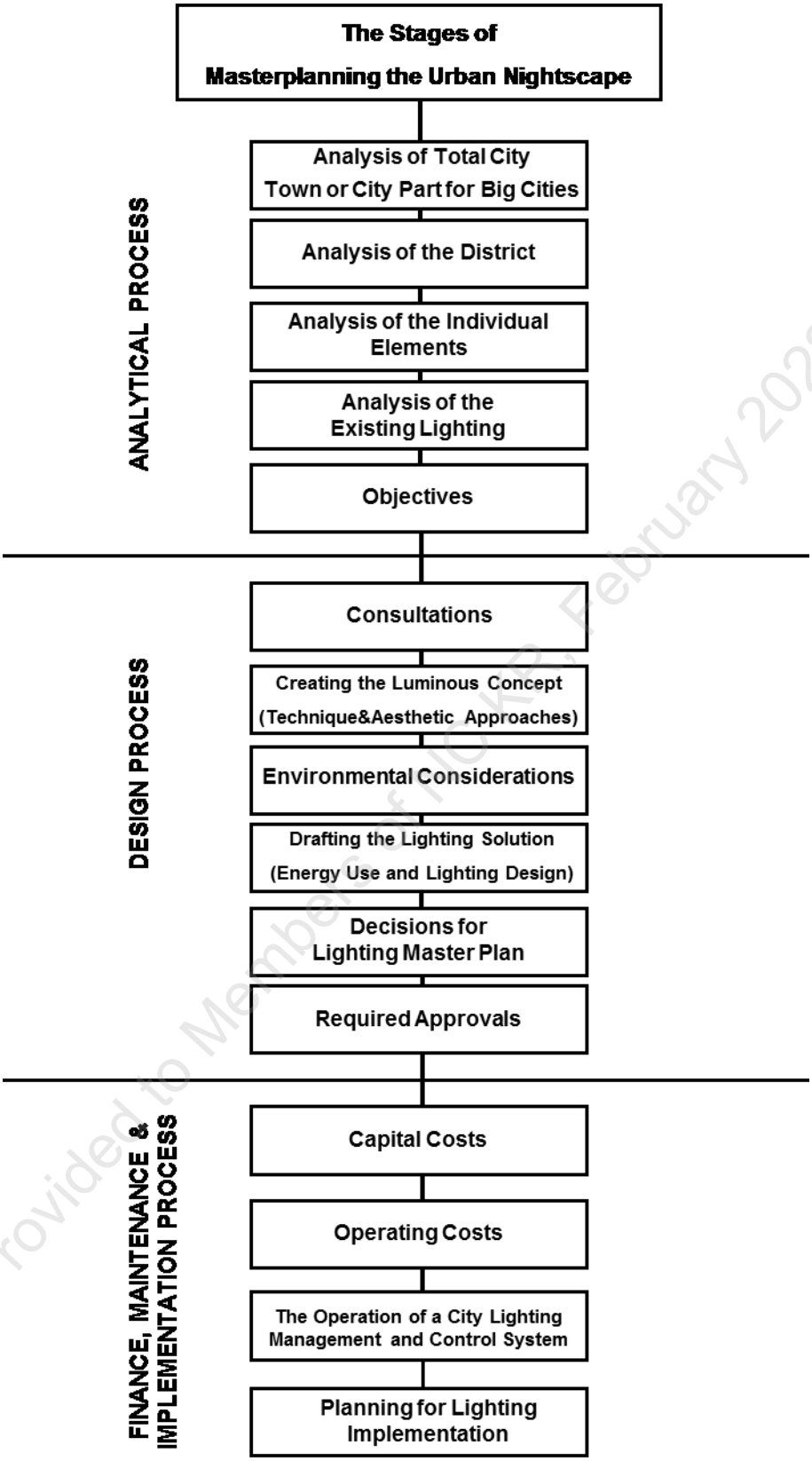


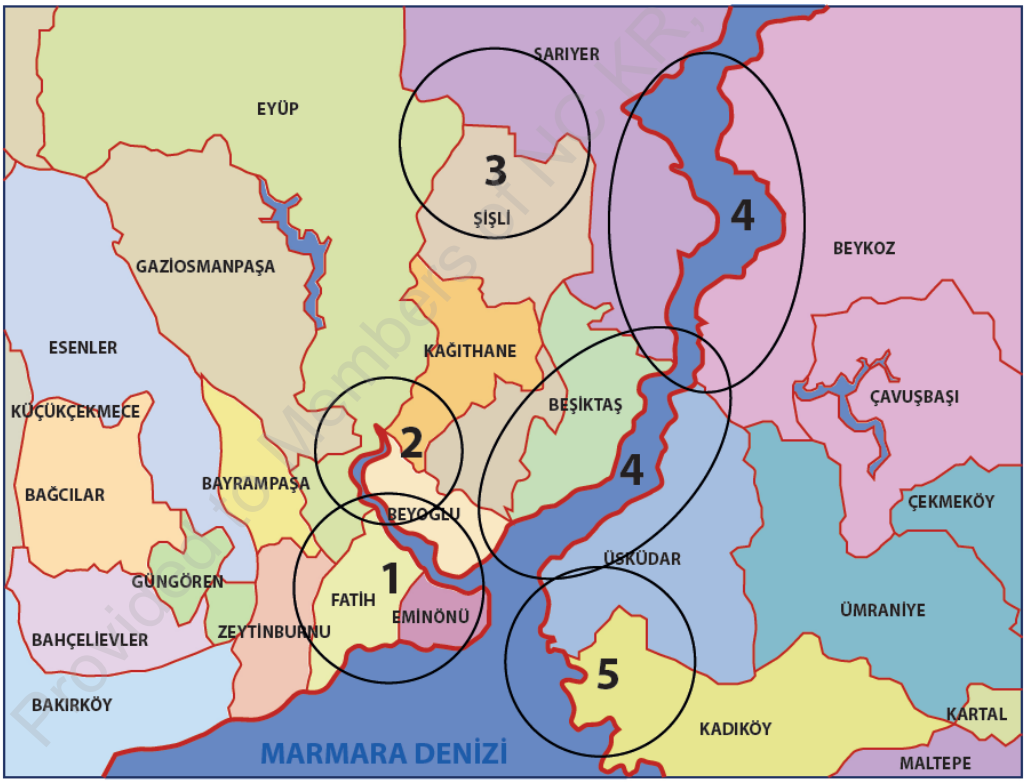
Figure 3 — Stages of masterplanning the urban nightscape

5 Analytic process

The first stage in preparing a master plan is the analytic process. This process requires a detailed study of the total urban area or, if the exercise is restricted to agreed areas, selected section(s) of the city. The resulting data will form the basis of the lighting planning process.

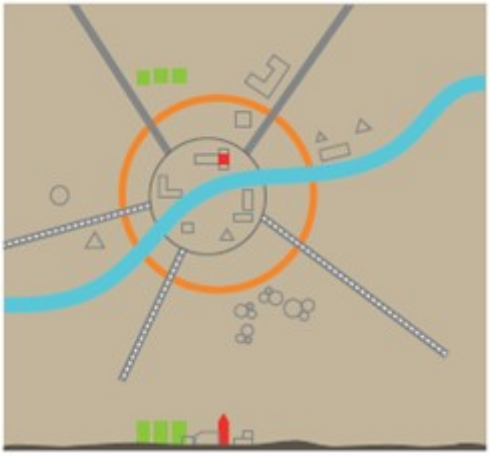
5.1 Analysis of a whole city, a town or major districts within large cities

The lighting masterplanner should start by analysing the city's characteristics. In this analysis, factors such as the scale of the city, its overall area and the addition of contemporary to older settlements should be considered. For example, cities frequently have two, or more, characters due to differing historical and contemporary developments. In such a situation, lighting plans must be separately prepared for individual regions and these should acknowledge the characteristic features of each. For example, in Istanbul, areas such as the Historical Peninsula, the Bosphorus, and Galata-Pera regions involve multiple usage criteria as shown in Figure 4. Such criteria have, over time, informed differing values and priorities, which collectively determine the overall visual and functional character of a city. Cities that have a particularly dominant profile may also have other important characteristics. For example, a historical city can also be a university city, a cultural-art city or a thriving commercial city. It is important to consider these aspects in preparing a lighting masterplan as shown in Figure 5 (a,b,c) and Figure 6. (Serefhanoglu Sozen et al., 1995; Serefhanoglu Sozen & Bostanci, 2001; Serefhanoglu Sozen et al., 2005; Gardner, 2001)



1- Historical Peninsula (historical, commercial),
2- Galata – Pera Region (historical, entertainment),
3- Levent- Ayazaga Regions (new settlements) – (commercial, high-rise office buildings),
4- Bosphorus Region (historical, residential),
5- Kadikoy Region (historical, cultural, commercial, residential)

Figure 4 — Analysis of Istanbul showing the important regions
(Figure provided by Serefhanoglu Sozen & Baskan)



a) **Analysis of the city as a whole determines its characteristic elements. (e.g. the ring road, the square, the river, the palace, etc.)**

b) **Various districts can be chosen in which to employ lighting for functional or subjective reasons (e.g. the historic centre, the waterside district, a park, etc.)**

c) **Buildings or places that are of interest by virtue of their architecture, history, art or symbolic significance can be lit to explain and emphasize these assets**

Figure 5 (a,b,c) — Examples of the different stages of a lighting master plan
(Figures provided by Serefhanoglu Sozen, Baskan, Tasdelen)

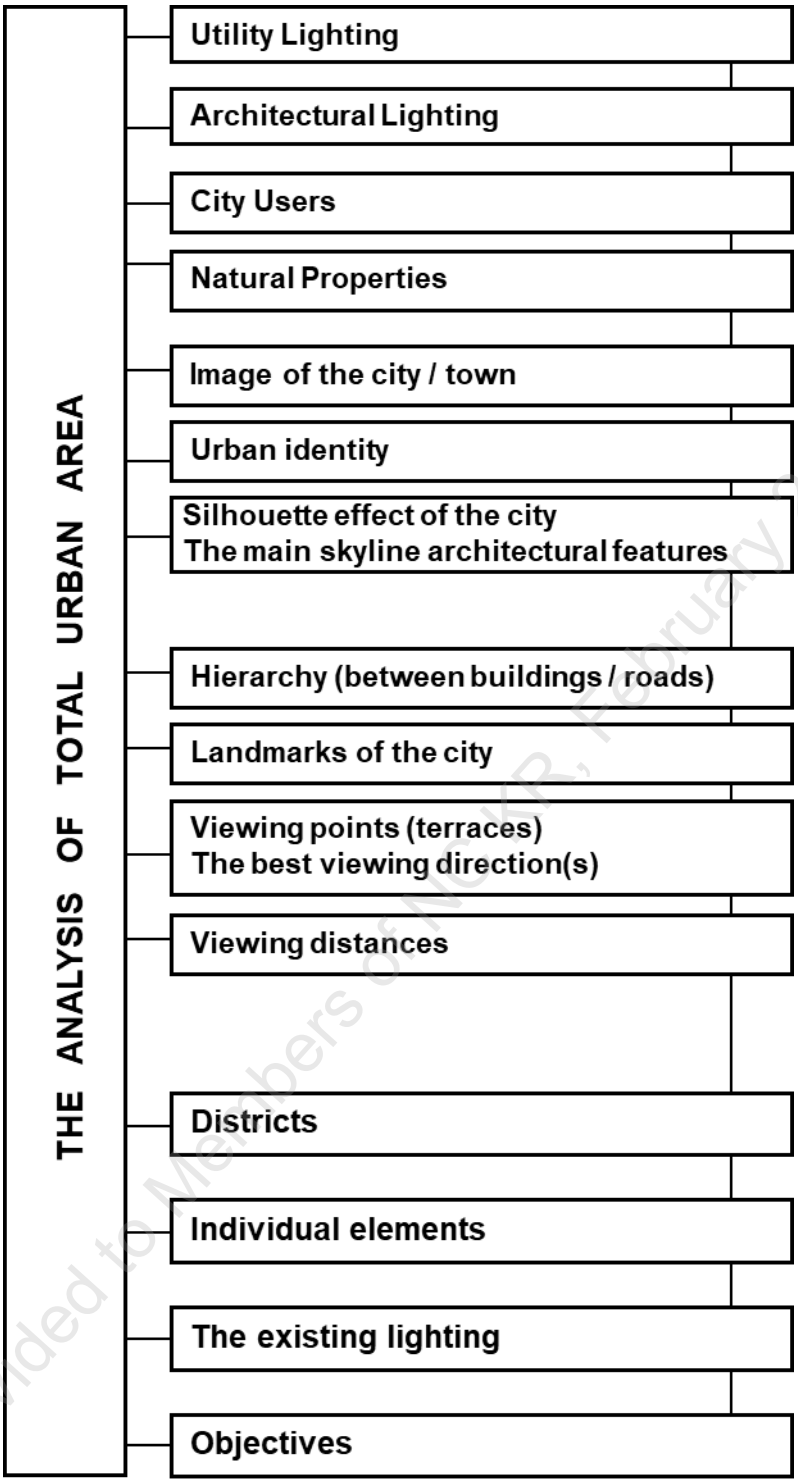


Figure 6 — Analysis of the total urban area

5.1.1 Analysis of utility lighting subjects

In analysing a city's existing and future lighting needs, both utility and architectural lighting should be considered as of equal importance in the overall nightscape.

The main areas requiring utility or amenity lighting include:

- motorized traffic routes such as: main arterial roads, ring roads, streets;
- squares and plazas;
- pedestrian footpaths and sidewalks;
- pedestrian zones, playgrounds;
- cycle paths;
- parks and green spaces;
- waterside areas;
- principle gateways into the central city area;
- major traffic nodes on the city's approach roads;
- sports areas;
- commercial areas;
- industrial areas.

These constitute the transportation and 'working' networks of the city. The lighting for these components is important not only in terms of the general night-time view of the city, but also in relation to traffic safety. Highway lighting has to be designed to allow for a variety of factors such as road category, width and traffic capacity. Additionally, structures or buildings adjacent to highways can be considered as gateways or portals that constitute a point of entry and a symbol of the city. Road lighting that is based on the consideration of such characteristics assists in the legibility of a city's layout from key sightseeing locations and can also emphasize crossroads and squares as important nodal points within the city.

Outdoor spaces where non-motorized traffic is involved (pedestrian areas, parks, etc.) have to be carefully analysed, especially in the variety of their usages and thus their correlated visual needs. In such areas, the visual environment plays an important role for the users. In particular, it should help the citizen in orientation, and be adapted to the main visual tasks (Figure 7).

Figure 7 — Analysis of main roads and areas for traffic and pedestrians (City of Balma/France) (Laganier, 2000)

5.1.2 Analysis of architectural lighting subjects

The subjects of architectural lighting which are important in characterizing a city at night are frequently many and varied. The most important candidates for architectural lighting are normally the city's natural or topographical features, buildings, structures such as fountains or monuments and set landscapes. Their function, architectural form, and historical or contemporary value all contribute to the symbolism of the city. Figure 8 shows the analysis of the architectural elements of Saint Michael's Quarter, Ghent/Belgium.

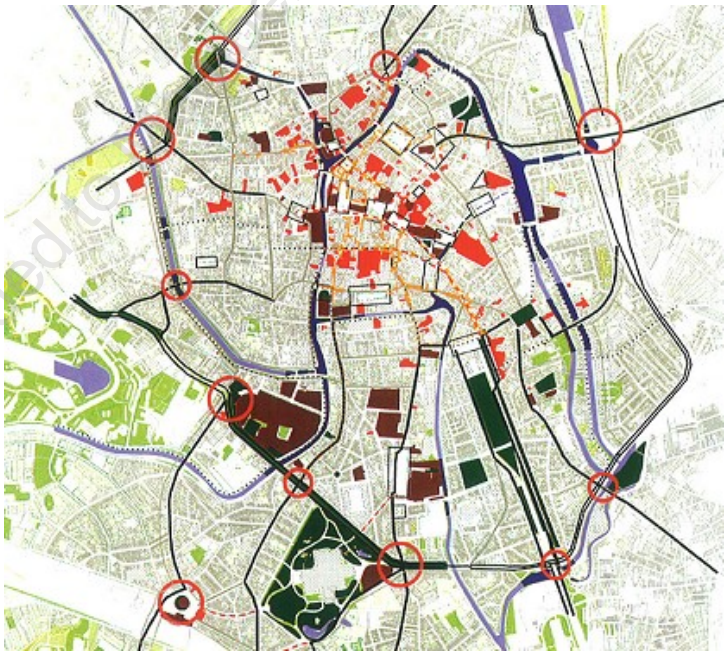


Figure 8 — Analysis of the architectural elements (Light Plan of the Ghent city centre/Belgium) (Philips, 2004)

5.1.3 City users

Those who use the city at night are the natural audience for the designed presentation of the nightscape. This includes residents, visitors, and tourists, both national and international. Whilst utility lighting is obviously the most important aspect of lighting for local residents, particularly in terms of safety and security, it is reasonable to assume that they will also be receptive to the beauty of their city at night and the appreciation of the lighting in their neighbourhood at night, both a source of satisfaction and of potential pride. In order to stimulate and maximize the potential of an area's evening economy, it is necessary to create a night-time environment which highlights those elements of the city's fabric which can be made visually attractive by the addition of well-designed architectural lighting. Patterns of use within a given precinct should be analysed to enable city users, and especially tourists, to use the area comfortably and securely during the night-time period.

5.1.4 Natural properties

Many towns and cities have special characteristics such as their topography or natural location, which makes them particularly attractive. Natural features are the main factors that determine the structure and settlement of a city. Such situations are exemplified by canal-based cities such as Venice and Amsterdam, cities that are set on rivers such as Budapest and Bangkok and coastal settlements such as Istanbul and Sydney or attractions with rocks and waterfalls such as Niagara. These natural features are important in creating the city's identity and should be incorporated within a lighting masterplan.

5.1.5 Image of the city or town

The night-time presentation of a town or city is an important factor in its overall identity. Natural features such as mountains, valleys, hills, rivers, lakes, or coastlines all contribute to this presentation and together with the manmade structures are important foundations of its image and silhouette. As an example, some old religious and classical buildings can create historical city images and some modern structures create interesting new city images.

5.1.6 Urban identity

As with human beings, cities, and districts within cities, invariably promote their individuality. Images which strongly identify a city can either derive from history or can be introduced by creating a particular image for newly planned cities or city regions. However, under appropriate conditions, new images can be created for old cities and their districts.

Urban identity and imagery is formed by different features of the city such as:

- natural assets;
- built environment;
- basic functional aspects e.g. industry, commerce, education, entertainment, culture or arts;
- architectural heritage;
- contrasting classical and contemporary architecture;
- major or iconic works of public art;
- displaying the digital world in the form of large scale electronic screens.

In planning the nightscape, it is therefore important to analyse the city's characteristics and prepare a lighting policy that can carry this identity into the night. Lighting that is not carefully planned and installed can only diminish and confuse the image and legibility of the nightscape. The aim is to enhance the city, not to compromise its image at night.

5.1.7 Silhouette effect of the city – main skyline architectural features

Silhouette is valuable component of the urban image. Buildings and natural components can create a city's silhouette at dusk. For example, palaces or castles on a hill can create varied silhouettes when viewed from different vantage points. Or, in historic cities, the silhouette of the historical buildings and, in new regions, that of the contemporary buildings can create commanding, and contrasting, silhouettes at dusk. In such situations, these differing silhouettes, which can often be seen within the same view, should be identified and carefully revealed through appropriate lighting. Figure 9 (a,b,c) shows silhouette effects of some cities. In the silhouette condition, topographical elements near rivers and lakes can play a role in revealing rich views of distant buildings and is highly effective in creating a strong background. However, in some cities, the layers of buildings obscure one another and the silhouette forms are therefore simpler. In the silhouettes of some cities important buildings inevitably create a landmark statement e.g. the Big Ben Clock Tower in London and the Eiffel Tower in Paris. (Serefhanoglu Sozen et al., 1995; Serefhanoglu Sozen et al., 2005)

a) Modern city (High-rise buildings)

b) Historical and modern part of the city

c) Historical city

Figure 9 (a,b,c) — Main skyline architectural features and silhouette effect of some cities
(Figures provided by Serefhanoglu Sozen, Baskan, Tasdelen)

5.1.8 Hierarchy between buildings

If there are many buildings or structures within a silhouette view, it is important to check both local and long distance viewing locations. Using differentiated luminance values and/or colour characteristics is a matter of primary importance in creating a successful skyline view. As general guidance, for the remarkable luminance effect, the contrast ratio should be

- 3/1: just noticeable;
- 5/1: low impressive;
- 10/1: high impressive

(CIBSE/ILE, 1995) (see also 6.2.2).

Figure 10 shows the hierarchy in an illuminated buildings skyline view.

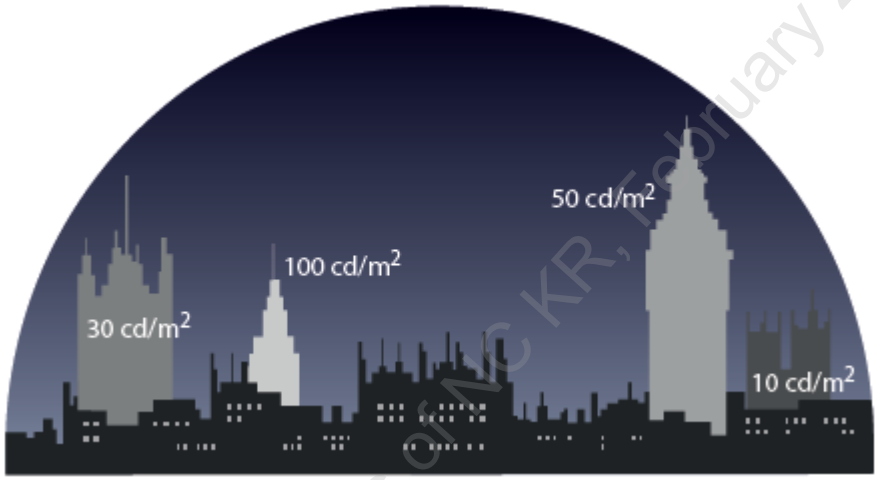


Figure 10 — An example of a lighting hierarchy between illuminated buildings
(Figure provided by Serefhanoglu Sozen, Baskan, Tasdelen)

5.1.9 Landmarks of the city

Landmarks are key points of visual reference in the city and are frequently used as clues for identification and even of structure. Such elements can be topographical, historical or contemporary and are increasingly relied upon when a journey becomes more and more familiar and should therefore be as visible by night as they are in daytime. The visualizations in Figure 11 (a to f) show how a number of world famous landmarks have become symbols as well known by their illumination at night as by their normal daytime appearance.

As internally illuminated street furniture and advertising elements become more common in urban areas, these become important within the overall urban nightscape and need to be seen as valuable parts of the overall design. In this respect therefore, their effects on the overall lighting should not be overlooked and such elements should therefore be factored into the lighting masterplan. (Serefhanoglu Sozen et al., 2005; Lynch, 2000)

a) The Leander's Tower / Istanbul

b) The Eiffel Tower / Paris

c) The Statue of Liberty / New York City

d) Christ the Redeemer Statue / Rio de Janeiro

e) Big Ben / London

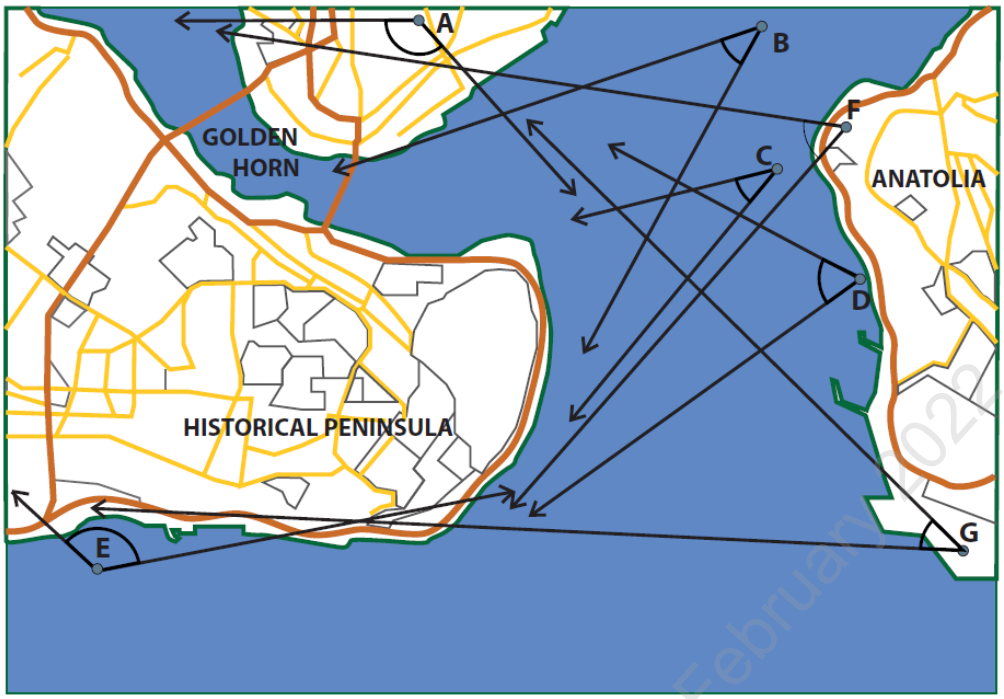
f) Maishima Incineration Plant / Osaka

Figure 11 (a, …, f) — Landmarks of different cities
(Figure provided by Serefhanoglu Sozen, Baskan, Tasdelen)

5.1.10 Viewing points, terraces and directions

In presenting a city to local and foreign tourists, or for the citizens' appreciation, viewing points and terraces become important urban design elements. These locations are usually the highest points or areas and provide wide night-time viewing angles of the city.

When identifying the viewing locations of a city silhouette, it is important to choose a viewing direction and angle that provides an effective image. Viewing points that are identified when wandering the city as a pedestrian as well as those viewed from vehicles should also be determined. For example, in Figure 12, there are multiple viewing points, directions and angles, all of which are of importance in displaying the Historical Peninsula of Istanbul. (Serefhanoglu Sozen et al., 2005)



A – from Galata – Pera region - European side
B – from Bosphorus
C – from Leander's Tower
D – from Asian side
E – from European side
F – from Uskudar region – Asian side
G – from Kadikoy region – Asian side

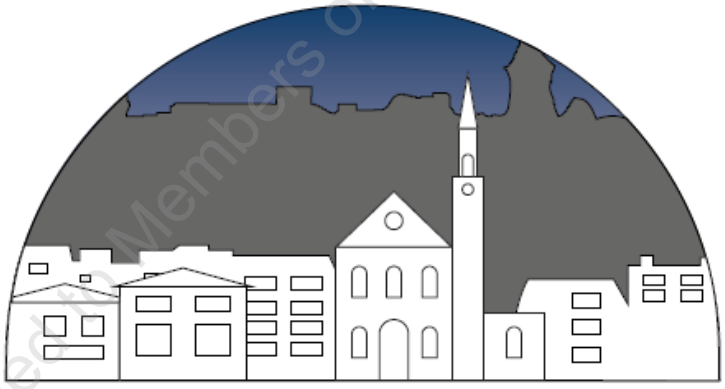
Figure 12 —Typical perspectives from different locations in the city
(Figure provided by Serefhanoglu Sozen & Baskan)

5.1.11 Viewing distances

In analysing the city, the distance of viewing points from their subject is as important as the direction of view. Distances relate to the viewing angle and the visibility of the silhouetted subjects. If the distance is too great, illuminated surfaces are perceived by their collective luminance and too many buildings or structures can a create lack of clarity of the individual components. But at closer range, fewer subjects enter the picture and, where luminance differentials exist, these can be perceived and more detail can be identified. Figure 13 (a,b,c) shows different distances and their effect on the visibility of detail. (Serefhanoglu Sozen et al., 2005)

a) Long distance

b) Medium distance



c) Short distance

a) Long distance, viewing angle is large; subjects in the silhouette are perceived as an indistinct area of luminance.
b) Medium distance, viewing angle is smaller; number of subjects in the silhouette is reduced.
c) Short distance, viewing angle is small, number of subjects in the silhouette lessen or are individually visible.

Figure 13 (a,b,c) — Differing distances and their effect on the visibility of detail
(Figures provided by Serefhanoglu Sozen & Baskan)

The foregoing indicates that surface luminance values should relate to the range of subjects within a viewing area, the hierarchy between these and their distance from the viewing points.

5.2 Analysis of the districts

Varieties of districts are the basic components of a city's image. The physical characteristics may consist of different aspects, such as texture, space, form, building type, symbol, activity, cultural aspects, topography, and in a closely built area, homogeneity of facade, material, colour, modelling, and ornamentation. All these provide the basic physical variations that create the identities of individual districts. District names can also help to give identity to districts, even when a particular district does not establish a striking contrast with other parts of the town or city. (Lynch, 2000)

The basic approach is to study and analyse those special characters or different functions within the life and/or economy of the city. The qualities that give the identity of the district are listed below.

- Historical district / modern district;
- Regions of art, culture, entertainment;
- Industrial district;
- Commercial, retail regions, exhibition areas;
- Residential areas;
- Parks, gardens, cemeteries, greeneries;
- The main attractive regions;
- The culture of the inhabitants;
- The social identity of the neighbourhood.

5.3 Analysis of the individual elements

Together with the city and district analysis, detailed analysis of individual elements is also needed. In the analysis of individual elements, studies should be made according to the criteria shown below.

Criteria of the analysis:

- Functions
- Historical profile
- Appearance
- Image qualities[2]
- Symbolic quality
- Architectural properties
- Artistic merit
- Viewing points
- Silhouette effects
- Viewing directions
- Perspectives
- Viewing distances
- Building properties (shapes, dimensions, colours)
- Promotional effect
- Sociological profile
- Cultural identity of their inhabitants and their customs

5.4 Analysis of the existing lighting

It is normally the case that a lighting masterplan will be developed for an existing city with existing lighting. Under these circumstances, the lighting planner will need to closely consider all forms of existing lighting in terms of its quality, variety, appropriateness, effectiveness,

[2] to give vivid impression with different properties such as colour, shape, texture, structure, etc.

performance and visual cogency, considering the social aspect, the landscape at night, the energetic and environmental issues. It is highly likely that the masterplan will include recommendations to modify or renew, or perhaps remove, existing lighting. This could be because existing lighting is creating excessive glare, a disparity of luminance or colour temperature values that cannot be successfully integrated with the newly planned lighting scenario, or simply due to non-compatibility of the equipment with current standards in terms of overall design quality and energy efficiency.

5.5 Objectives

The specific objectives of a lighting masterplan should take inspiration from the day-lit city but, in doing so, should recognize the major differences that influence the image and perception of the city from day to night. Though the basic objectives of revealing the city by either day or night are complementary, the outcomes at night are distinctive. Examples of such objectives are listed below:

- Provide safety to persons and properties.
- Enable outdoor activities in a socially positive environment.
- Create a distinctively night-time signature image of the city.
- Enable both visitors and citizens to appreciate the city's self expression.
- Reveal historical and architectural heritage in a selective and discriminating manner.
- Animate the contemporary city image.
- Express the cultural life of the city.
- Help to create a successful night-time economy.
- Create an attractive night-time environment.
- Provide security and guidance in residential areas.
- Give satisfaction and pride to the citizen of their own neighbourhood.
- Encourage commercial and business owners to improve their street elevations and lighting there of.

Larger, and developing, cities offer the opportunity to use lighting to create distinctive, strongly characterized, presentations of their differing precincts and zones. A city which has a clearly defined historic city centre, as well as an established contemporary commercial precinct and, perhaps, an area of 'cutting edge' development such as an Information Technology (IT) zone, offers the potential to characterize these in a widely differing manner through the creative and appropriate use of lighting.

6 Design process

The first stage of preparing a lighting masterplan consists of the extensive process of analysis described thus far. This must include the achievement of an in-depth understanding of the desired balance between the provision of essential utility lighting and the elective lighting of architectural and natural assets. Additionally, it is necessary to form a clear assessment of publicly and privately owned property, a full survey of existing lighting provision and the establishment of a set of basic macro-design directions for the characterization of individual precincts, zones and regions within the city. When these issues are well secured it is possible to move to the next stage, that of preparing firm and well defined strategies, in the degree of detail required to steer the ultimate lighting implementation programme in a direction that supports the objectives of the masterplan.

6.1 Consultations

Some or all of the following organizations should be consulted prior to any outline designs being drawn up. This is to ensure that their views can be assimilated into the overall concept so that, at any later approval stage, they will add their support to the preparation and implementation of the lighting masterplan:

- highway lighting engineers,
- urban planning departments,
- city economic departments,
- chambers of commerce and other business associations,
- residents groups,
- women's groups,
- energetic and environmental groups,
- information technology (IT) department,
- heritage groups,
- astronomers – professional and amateur,
- tourist authorities,
- police,
- sociologists,
- other interested groups

6.2 Creating the luminous concept

A guiding principle in the formation of a practical and effective lighting masterplan is that both, the essential utility (or amenity) lighting and the architectural lighting should be considered in parallel, as two contributions to the total visual image of the city at night. However, it is essential that any architectural lighting scheme does not impact the essential utility lighting in a negative way: utility lighting, in the form of road, street, footpath and security lighting remains a constant prerequisite for the safe and comfortable use of a city at night. However, the corollary to this is that it is only the architectural lighting that has the potential to convert a safe but dull, urban nightscape into one of delight, attraction and vibrant economic success.

6.2.1 Choices for lighting

Whilst a masterplan will need to include utility lighting as an essential, and acknowledge that its provision is dictated by considerations such as traffic density, prevalence of crime in a given area or the need to comply with statutory requirements, the same cannot be said for the provision of architectural lighting.

The question as to which buildings, structures or natural assets can, and should, be lit will invariably rest on issues of capital and operating costs as well as justification in terms of energy usage. This fact indicates a need to establish a set of guiding priorities based on the varying attributes and importance of the subjects. It is unlikely that all potential subjects for lighting can be included within the masterplan and it will therefore be necessary to make decisions as to which should be excluded, and why.

It is helpful to consider the use of a grading and prioritization system such as the one shown as an example in Table 1, Table 2 and Table 3 (Serefhanoglu Sozen et al., 1995; Serefhanoglu Sozen et al., 2005; Kasli & Serefhanoglu Sozen, 2007).

Table 1 — Criteria for the lighting of historical buildings and structures

Subjects	Function	Historical meaning	Appearances	Image quality	Symbolic quality	Architectural properties	Silhouette effect	Distances	Promotional effect	Total points
Historic buildings	10	10	10	10	10	10	10	10	10	90
e.g. Palaces Castles Relig.Build. Other										
Structures	10	10	10	10	10	10	10	10	10	90
e.g. Bridges Towers Viaducts Other										

Table 2 — Criteria for the Lighting of Contemporary Buildings

Subjects	Function	Appearances	Image quality	Symbolic quality	Architectural properties	Silhouette effect	Distances	Promotional effect	Total points
Contem.build.	10	10	10	10	10	10	10	10	80
e.g. Commercial Industrial Administrative Cultural Educational Other									

Table 3 — Criteria for the Lighting of Urban Spaces and Public Artworks

Subjects	Function	Image quality	Symbolic quality	Artistic merit	Viewing points	Distances	Total points
Urban spaces	10	10	10	10	10	10	60
e.g. Parks Gardens Pedest.areas Squares Other							
Artworks	10	10	10	10	10	10	60
e.g. Monuments Statues Fountains Sculptures Pavillions Other							

Tables 1 to 3 offer the masterplanner an example of a matrix which can provide a basis for a hierarchy of lighting elements based on cost, visual weighting and the functional or other status of the subjects. Illustrations of how this may work are given in Table A.1 and Table A.2 in the annex.

6.2.2 Luminance levels and luminance contrast ratio

Under daylight conditions, the luminance of surfaces of varying reflectance value constantly changes. Daylighting levels, and the reflectance of surfaces, are the factors that determine such luminance differences. These occur between parts of a building that are in sunlight and those that are in shadow. Differing luminance values play a critical role in shaping the perception of three-dimensional objects. In developing a masterplan for artificial lighting it is

essential to predict a range of luminance values which provide the necessary degree of visibility under differing conditions. Failure to do so results in a loss of control of the overall luminous scenario and the ability to present the nightscape in a cogent manner. Significant negative results arise in a situation where a masterplan does not consider and prescribe a range of absolute luminance values, and their contrast ratios, as an essential tool in the creation of a successful night-time image. Critically, this can lead to a negative public and political image of architectural, or elective, lighting as being unnecessary and unjustifiable in a world concerned about energy conservation and reduction in global warming.

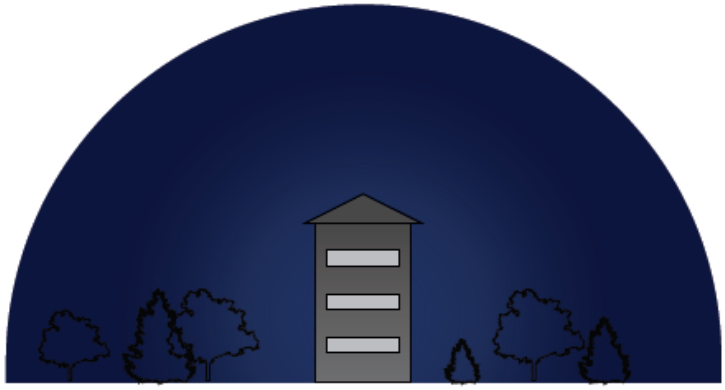
Detailed negative results also include:

- a potential for escalation in lighting levels brought about by building owners seeking to have their building become brighter than that of their neighbours;
- a lack of legibility of the overall city at night;
- unjustifiable increases in lighting related energy usage;
- night sky light pollution and spilled light in general;
- increases in the capital and operational expenses of the lighting;
- a dislike by the citizens if the project is contrary to their social beliefs and cultural identities.

Most citizens are acclimatized to perceiving their city under high levels of natural light for the majority of time. Consequently there is a tendency to prefer levels of artificial lighting which are as high as possible in order to feel safe, secure and comfortable with one's surroundings. However, a planned approach to the overall lighting of a city must acknowledge that not only is a consistently high level of artificial lighting impractical from the point of view of cost, energy and environmental degradation, it is also visually impractical. This is because a successful interplay of luminance values, resulting in a varied and lively presentation of the nightscape, requires to be based on a luminance contrast ratio of greater than 3:1. Less than this ratio, even if provided at high absolute luminance values, will result in visual monotony and a lack of variety, particularly when viewed from distant vantage points. Any attempt to create a visual hierarchy will also become futile. (CIBSE/ILE, 1995)

6.2.3 Surroundings and background

Both the brightness, and luminance, of the general surroundings and that of the environmental background to the buildings to be lit are important. If the background and surroundings are dark, a relatively small amount of light is needed to make the building lighter than the background (Figure 14a). If there are other buildings in close vicinity in which interior lighting is active at night, the lit windows will give an even greater impression of brightness. In this situation more light may be needed for lighting the elevation of the building effectively (Figure 14b). If the background and the neighbourhood are bright, more light may be needed to achieve the contrast between the building and its background and surroundings. It is also possible to use a colour contrast instead of a luminance contrast (Figure 14c). (Serefhanoglu Sozen et al., 2005)



a) Dark background

b) Less lit background

c) Lit background

Figure 14 (a,b,c) — Contrast between lit subjects and background
(Figures provided by Serefhanoglu Sozen, Baskan, Tasdelen)

6.2.4 Colour of light and application

The colour characteristics of light are a major contributor to the quality of external lighting. The key characteristics are the colour rendering performance and the correlated colour temperature (CCT) of the light sources. Colour rendering refers to the ability of the light source to reveal colour correctly in relation to a defined index known as the Colour Rendering Index (CRI), which is graded from 0 to 100. A higher index figure indicates a greater ability to reveal colour fully and naturally, as is experienced under daylight conditions. The correlated colour temperature of a light source is expressed in kelvins and refers to its degree of visual

warmth or coolness. Higher temperature values indicate a cooler visual quality of light. Additionally, the colour of the light source can be characterized by chromaticity coordinates such as those of the CIE 1931 standard colorimetric system (x, y).

The reference colour of an object is considered to be the colour as perceived under daylight. However, daylight colour characteristics change throughout the days and the seasons. While it is important to create the same colour impression for identical materials, when differently coloured materials are involved, such colour variations can be emphasized by employing different types of light source. While some types of gas discharge lamps do not possess good colour rendering characteristics, many of the colours found in building materials can still be adequately rendered by such lamps. Some yellowish materials appear comparatively natural under the light of high-pressure sodium lamps. But, under the same light source, blue materials appear unpleasant and drained of their natural colour. White-light LEDs are now capable of producing colour temperatures both more consistently and in a wider range than almost any other light source. They are also in many cases surpassing conventional sources in their ability to render colours accurately. Coloured light can be used to characterize materials: red for brick, green for grass and foliage, blue for water. Climate and environmental temperature are also strongly associated with colour. Generally, light inclined to the red end of the visible spectrum suggests warmth, whilst light biased to the blue end of the spectrum is more likely to have a cooling influence. The use of coloured light also depends on experience and cultural background. Varying colours and colour temperatures can provoke wide ranging emotional responses in different parts of the world. Additional criteria such as environmental consideration may guide the choice for certain colour temperature.

6.2.5 Colour contrast of light

Because the reflectance of a surface is an important determinant of its luminance, this value should be taken into consideration when planning the total presentation of a building or a series of buildings. Not only do reflectance factors influence the decision as to whether or not to light a building, they also determine the amount of light and associated energy required to reveal a building effectively in the context of its surroundings and importance within the nightscape.

In addition, or as an alternative, to the use of varying luminance values, lighting colour characteristics, and particularly the correlated colour temperatures, can be considered as a useful tool to create contrast and to contribute to a visual hierarchy, either in terms of the lighting of an individual building or the lighting of a group of buildings in a panoramic setting. Relatively small differences in the correlated colour temperature of light sources can achieve subtle, but important, changes in emphasis and contrast.

The question of using either saturated or tinted colouration in lighting is one which requires close consideration. Coloured lighting is a powerful element within a nightscape; when used sensitively and appropriately it can create a pleasing counterpoint to white light and can also introduce an element of delight and surprise into the night-time revelation of a building. However, when used indiscriminately, it can overwhelm the architecture and create a disproportionate degree of attention to the lighting itself. An additional concern is that it is easy to tire of an excessive and prolific use of coloured light. In this regard, the ready and convenient use of coloured LED light sources should be considered with care. It has never been technically easier or relatively cheap, to introduce saturated colour, either on a static or dynamic basis, than it is today. LED technology makes it possible today to work not only with saturated colours but with all shades of colours. This very ease of use implies a need for caution. Note that for this type of application, CCT is not relevant and the colour of the light source shall be expressed by chromaticity coordinates, mainly those of the CIE 1931 standard colorimetric system (x, y).

Guidance on the use of colour should be considered an important component in the preparation of a lighting masterplan. It is likely that its use in some areas of a city will be more appropriate than in others. For instance, it is more likely that colourful, and possibly dynamic, lighting will be justified in the entertainment quarter of a city and less likely in its residential

suburbs or civic central area, although soft-coloured and fluid dynamic lighting is now often used throughout the city.

A masterplan should not seek to suppress or discourage the exuberant use of colour in light where this is appropriate; rather it should seek to ensure that the visual impact of colour is understood and respected.

6.3 Environmental considerations

It is clear that any lighting installation, yet alone a total urban lighting programme, will affect the environment. A lighting masterplan should therefore address the environmental issues arising from basic lighting design guidelines through to operational and maintenance considerations.

Three key issues to minimizing the environmental impact of lighting are:

- luminance level adapted to the users activities and the visual scenes;
- optimization of the energy used in individual installations, both in terms of basic power consumption of the light source, light spectrum, scenography (dimming control), and the overall efficiency of the complete luminaire;
- control of wasted light output. Additionally, the masterplanning process is itself a key determinant of the impact of lighting on the environment, because it is at the macro-planning stage that the approximate number of individual installations is determined and the potential for excessive lighting can be discouraged.

In any design for outdoor architectural lighting, in order not to over light, waste energy, cause obtrusive lighting or night sky pollution, it is important to ensure that a suitable luminance design is achieved that, while taking account of the fundamental requirements of the masterplan, keeps overall lighting levels to a minimum.

CIE Publication 150:2017 *Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations* (CIE, 2017) gives guidance on how to achieve these aims, which together with adherence to current standards and ordinances should help ensure that all environmental considerations are met.

In detail, the masterplan should address the energy and associated environmental costs which arise during the following:

- design of individual installations,
- correct installation of the lighting,
- operational hours of the lighting,
- maintenance of the lighting systems,
- disposability costs.

The energy costs of a city's lighting system are fundamentally related to good design. The initial design should be based on a masterplan which includes the following key factors:

- A guide to the number of elements which are to be lit. This number must be commensurate with the achievement of a cogently lit city, or part thereof, whilst not encouraging excessive or unnecessary lighting.
- Appropriate luminance guidelines to create an attractive overall view of the nightscape whilst keeping the lighting levels to a minimum.

In any design for outdoor architectural lighting, in order not to over-light, waste energy, or cause any obtrusive light, it is important to take into account the ambient lighting. Four widely accepted 'Environmental Zones' used in lighting are shown in Table 4 (adopted from CIE 126-1997 (CIE, 1997)).

Table 5 shows suggested luminance level limits for architectural applications in these zones (CIBSE/ILE, 1995).

Table 4 — Environmental zones

Zone	Lighting environment	Examples within urban areas
E1	Intrinsically Dark	Large parklands and natural spaces
E2	Low District Brightness	Centre of large squares, small parks, some residential areas
E3	Medium District Brightness	Some residential and small business areas
E4	High District Brightness	City centres and other busy commercial areas

Table 5 — Luminance level limits

	Luminance level (cd/m^2)			
	E1	E2	E3	E4
Average*	-	5	10	25
Maximum**	-	10	60	150
* Maximum permitted values of average surface luminance ** Maximum permitted values for specific emphasis				

6.3.1 Obtrusive light – light trespass and sky glow

CIE Publication 150:2017 (CIE, 2017) should be consulted for technical data on obtrusive light in terms of light trespass and sky glow.

A lighting masterplan should prescribe the avoidance of light pollution, sky glow, or any other form of obtrusive light.

The problems of obtrusive light can affect many aspects of life, as indicated below:

Effects on residents:

- Under some circumstances outdoor lighting, such as street lighting, architectural building lighting, or a neighbour's lighting that illuminates the interior of an adjacent dwelling, can compromise privacy, create disturbance of sleep patterns and cause ill health for residents.

Effects on pedestrians:

- When the selection and installation of outdoor lighting is poorly implemented, there is a likelihood that glare will occur. It can also influence the actual safety (disability glare) and the comfort (discomfort glare) of the pedestrians.

Effects on human activities:

- Sky glow removes one of nature's greatest wonders – the night sky and star-scape. This can be as important to town and city dwellers as to those living in rural areas.

Effects on transportation systems:

- Automobiles
  The lighting of buildings, and other facilities adjacent to roads, can divert the attention of drivers and, through the creation of glare and other distractions, compromise traffic safety.
- Ships and aircraft
  Under some circumstances, urban and port facility lighting can compromise the clarity of marine hazard and shipping lane marker lighting.

Effects on plants and animals:

- Night-time lighting has a potential effect on plant physiology and plant ecosystems. When lighting is installed next to trees, shrubs and other plants, it may have an effect in the form of delaying the growth and defoliation period of these plants. Similar adverse impacts of night lighting can affect animal physiology and activity (disturb feeding, reproduction and orientation).

In order to avoid negative effects of lighting, its design and installation should:

- Use only the necessary requirements according to CIE 115 (CIE, 2010) for utility lighting.
- Use only the necessary degree of illumination required and not exceed a luminance value as referred to in Table 4 and Table 5 for architectural lighting.
- Where possible, aim lighting fixtures below the horizontal plane and locate equipment to prevent illumination across property lines.
- Install luminaires that do not create glare and also produce a controlled distribution of light which is profiled to the surface at which it is aimed. Ensure that the directed lighting is restricted to the subject area.
- Dim lighting over time to adapt the level to the usage and extinguish lighting when not required.

Note that all of these approaches also minimize energy waste.

6.3.2 Obtrusive light – glare

Glare is a major inhibitor of good visibility and the most dominant aspect of visual discomfort. Glare becomes a significant problem when exposed light sources can be seen directly. Luminaire type, location, mounting height and lamp intensity must be carefully selected to optimize light distribution and minimize glare.

In designing lighting schemes, it is imperative to respect the visual needs of nearby residents and drivers of vehicles. External building lighting schemes should never create discomfort or disability glare for drivers and pedestrians.

6.3.3 Obtrusive light – saturated and dynamic colours

The continuing development of LED technology, and its proliferation in external lighting, has resulted in a significant increase in the use of saturated colour for the lighting of building facades, multiple other built structures and natural features. This form of electronic ‘solid state’ lighting has also enabled the ready use of dynamic change and movement in colour and intensity. Whilst this technology has created a newfound freedom of expression, it also creates a danger of ‘colour pollution’ where the constant use and movement of colour leads to visual fatigue and repetition. To this extent colour, when misused or used excessively, becomes a form of obtrusive lighting.

Accordingly, colour should be used cautiously for specific purposes and not gratuitously. It can be used to reflect special occasions or celebrations and in the context of events such as ‘son et lumiere’ productions. If it is used as part of a permanent installation it should support, rather than intrude upon, the architectural expression of older buildings and, in the case of

contemporary structures, it should form an integral element, such as can occur when a building is designed with an ‘intelligent skin’ which responds to varying natural light or thermal conditions.

6.4 Drafting lighting solutions

An effective lighting masterplan is not a prescriptive document and should not seek to provide detailed solutions for all possible lighting permutations that arise in the urban context. Rather, it should provide strategic guidance to those responsible for the detailed design of individual installations and, in doing so, ensure that the principles defined within the masterplan are adhered to by all those engaged in shaping the nightscape.

To ensure that the masterplan is relevant to a lighting designer’s work it should include consideration and guidance of the following:

6.4.1 Energy usage, operational and maintenance considerations

The realization of a lighting masterplan will incur economic costs. It should therefore identify the approximate costs that are likely to arise from the design and implementation of individual installations. Costs are not only those of a capital or ‘first cost’ nature, or the cost of electrical power required to operate the installations, but also include hidden costs such as those associated with maintenance, ease or difficulty of equipment installation and subsequent access and the cost of managing compliance with the masterplan objectives.

6.4.1.1 Design stage

Costs, including environmental costs, of a multi-installation lighting system relate to its originating design, specification and correct implementation. The design should include the following basic factors:

- determination of the utility elements;
- compliance with CIE 115 (CIE, 2010),
- determination of the optimum number of non-utility elements which require to be lit to produce an overall cogent presentation of the city at night, or a selected area within it;
- compliance with the luminance limits defined in Table 5;
- consideration of dimming and extinguishing;
- consideration of the use of renewable energy sources and their efficient use;
- consideration of a city wide lighting control, maintenance and management system.

6.4.1.2 Application stage

In providing guidance on the selection of the correct type of lighting equipment, the masterplan should review altogether:

- choice of light sources;
- choice of luminaires or complete luminaire systems;
- choice of implantation;
- choice of lighting control and temporal profile along the nights, the weeks and the seasons.

6.4.1.3 Choice of light source

A wide range of light sources exists and continues to develop, particularly in the field of solid-state lighting. When energy usage is considered in isolation of other considerations, the source with a higher luminous efficacy, i.e. the ratio of luminous flux to the energy used by the

source, is frequently preferred. However, other factors such as the colour characteristics of the light, operational life, lumen output maintenance though life, physical size and cost, should be taken into consideration. For example, illuminating an entire city with yellow-coloured light is not justifiable solely because the luminous efficacy of a sodium lamp is higher than that of other light sources. The wide range of sources offers the lighting masterplanner much opportunity to broadly adjust and balance the appearance of individual components within the nightscape. This can be achieved through the allocation of selected 'white light' colour characteristics to individual buildings, or groups, as well as the thoughtful application of colour temperature variations to the lighting of landscaped and planted areas, waterscapes and distinctively differing precincts within the city.

The final choice of light source ultimately lies with the lighting designer of individual installations. However since the characteristics of light sources vary greatly, particularly with regard to colour appearance, it is important that a masterplan gives guidance to the use of differing sources as a form of overall planning tool.

6.4.1.4 Choice of luminaire or complete luminaire system

The efficient use of energy is partially determined by the correct choice of luminaire, in combination with the light source. The correct choice is one which:

- achieves high efficiency in terms of light output in relation to light source flux or, in the case of a complete luminaire system, such as a fully integrated LED based unit, high overall system efficiency, based on a power to light output ratio;
- limits the distribution of light to the surface in question through an efficient optical system; this also requires close consideration of the location of the luminaire in relation to the subject surface;
- is able to prevent glare from all viewing locations;
- is appropriately protected from environmental conditions which can reduce effective light output over time i.e. is correctly Ingress Protection (IP) rated;
- is of sufficient construction quality to ensure longevity;
- is corrosion proof in the case of use in saline environments;
- is readily maintainable and does not fail after multiple maintenance operations;
- is visually appropriate to its proposed location in terms of size and style;
- meets relevant electrical safety standards.

6.4.2 Utility lighting

CIE Publications 115:2010 (Road Lighting) (CIE, 2010) and 136-2000 (Urban Lighting) (CIE, 2000) should be consulted for technical data on utility lighting. In any city, utility lighting has become essential. Safe and efficient usage of the city at night is entirely dependent on such lighting. The lighting of roads, streets, footpaths, intersections and squares, provides for the safe movement of people and vehicles as well as a public sense of security. Because these functional lighting elements are visually predominant, and contribute significantly to the lit city, they form a key part of the foundational elements of a masterplan. Similarly, the functional lighting of sports, industrial, railway and port areas should be considered in relation to the city's visual characteristics. It is important that such forms of utility lighting be in harmony with the overall nightscape and that they are planned, or in the case of existing installations perhaps modified, to support the objectives of the lighting masterplan.

6.4.2.1 Roads and streets

Roads and streets should not be regarded as isolated urban elements but, at night, should be visually related to the city's usage and urban life. Squares, crossroads, tunnels, main arteries and ring roads are all components of the built environment. These differ in many ways:

- visibility and prominence;
- traffic capacity;
- status – local or through route;
- width;
- location in the city:
  - historic district,
  - new settlement,
  - commercial district,
  - entertainment district,
  - city centre,
  - beyond the city centre,
  - residential area;
- environmental factors (adjacent to sea, lake, riverside, green areas, scenic locations).

In specifying lighting for these utility elements, the following issues are considered:

- compliance with mandatory codes of practice;
- average road surface luminance;
- luminance uniformity;
- limitation of glare;
- lighting of surrounding areas;
- visual guidance.

6.4.2.2 Roads and streets – lighting arrangement systems and types of lighting elements

Differing roads and streets require differing technical lighting solutions in terms of location, centre-to-centre distances and mounting methods. In Figure 15, several general lighting arrangements are shown (adapted from CIE 132-1999 (CIE, 1999) and (Serefhanoglu Sozen et al., 2005)).

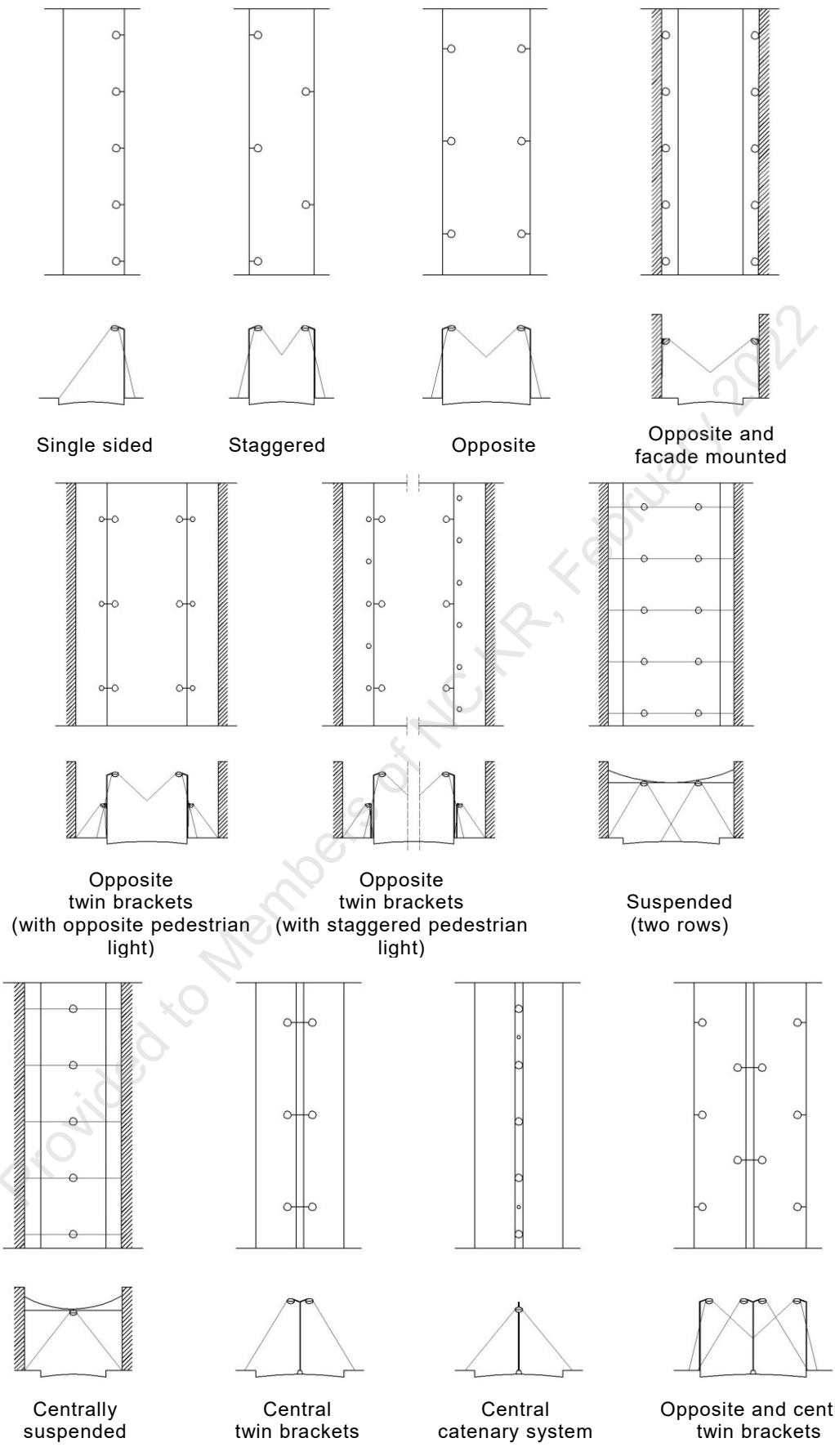


Figure 15 — Examples of mounting and location systems for road and street lighting
(adapted from CIE 132-1999 (CIE, 1999) and (Serefhanoglu Sozen et al., 2005))

Roads and streets can become a uniting element within their environment. Luminaires used for their lighting contribute substantially to both their day and night-time character. The following variables contribute to such:

- light distribution characteristics and associated glare control;
- dimensions;
- mounting height;
- suspended or surface fixed;
- mounting accessories – brackets, outreach arms or catenary cable system;
- design style;
- body colour.

In addition, all lighting elements should, if possible, be of a design style that harmonizes with other items of street furniture such as litterbins, seating, bus stops and signage. In this regard, consideration might be given to the use of multi-function lighting columns, which can support not only road or street lighting luminaires but also, traffic signal lights, banners, traffic and street name signage, cell phone transmission equipment and electronic information screens. The benefit of this approach lies in the minimization of the number of columns, poles and other support equipment, which normally create a high level of clutter at street level.

In an historical environment, a more traditional design of luminaire can be more appropriate than one of a contemporary design. A traditionally designed luminaire should nevertheless be equipped with an energy-efficient and effective optical distribution system, which creates a satisfactory level of visual comfort, whilst also providing the necessary levels of lighting. (Serefhanoglu Sozen et al., 2005; Kucukkilic & Serefhanoglu Sozen, 2007)

The width of roads in relation to their surroundings can be an important factor in the choice of their lighting. On narrow roads in old settlements, and in many conditions in which there are pedestrians and parked cars, it may be inappropriate to use column-mounted luminaires. In such conditions, wall mounted or catenary suspended luminaires can be considered.

Lit facades of buildings can contribute to road or street lighting but cannot normally be able to be factored into the engineering calculations for such lighting. This is due to its unpredictability in terms of operation. Nevertheless, this type of indirect contribution to a lit road or street can add an attractive third dimensional effect. Likewise, tree-lined roads can further benefit from the illuminating of the trees.

Finally, as an addition to conventional road lighting, point or linear way-finding lighting systems, which identify the road borders, can be installed within the road surface or adjacent to the road. This can make a strong urban design statement and have the result of emphasizing the road within its urban context.

6.4.2.3 Hierarchy between roads

The differentiation of roads according to their status and functions is a valuable tool in the lighting masterplanner's portfolio. Using varying qualities of lighting to define a hierarchy of roads and streets is a powerful way of revealing and emphasizing the grain of the city at night. This hierarchy can be provided by differences in the correlated colour temperature of light, the lighting level and the luminaires used, the heights of the light poles, the look of the lighting equipment, thereby not only facilitating the legibility of the city plan but also rendering the city in an attractive and memorable manner.

6.4.3 Urban spaces – pedestrian links, squares, local precinct centres

In recent times, the design of urban areas has developed substantially. Retail, commerce, community centres, industry and other areas of concentration of people have been separated

from residential zones with the wish to make living environments safer, adapted to outdoor activities, and the living experience more aesthetically pleasing. In all such areas equipment, including columns and brackets, should be designed as an integrated unit that will complement rather than detract from the aesthetic considerations of the area. In all these areas, light should be for the benefit for those who live there in order to afford not only safe, secure, and pleasant conditions after dark, but also, importantly, to play an aesthetic role in making the neighbourhood a more pleasant place for people to live in and a source of self-esteem for the communities.

6.4.3.1 Pedestrian areas

The most dominant visual elements in a pedestrian area are the pedestrians themselves, the street furnishings - mostly consisting of seats, litterbins, plant and flower arrangements, and the facades of the buildings bounding the area. For elements such as these, the vertical illuminance and/or luminance given by the artificial lighting often has greater meaning than its horizontal counterpart.

The visual tasks and needs of the pedestrian in many respects differ from those of the driver. Speed of movement is less and objects that are close to the pedestrian are more important than those in the distance. The surface pattern and texture of objects on the road and footpath are important to the pedestrian.

Urban task lighting should enable pedestrians to discern obstacles or other hazards in their path and to be aware of the movements of other pedestrians, friendly or otherwise, who may be in close proximity. For this, the lighting on both horizontal and vertical surfaces and the control of glare are important issues.

To ensure that the pedestrian can move over the road and footpath surfaces in safety, the horizontal illuminance must be adequate. Lighting of vertical surfaces aids the ability to recognize the intent and identity of other people. Further information together with suggested lighting levels is given in CIE Publication 136-2000 (CIE, 2000).

Moreover, the use of a space by pedestrians must not be limited to the single task of walking. Outdoor activities have to be holistic: they can include sitting, reading, socializing, playing, running, etc. The consideration of these activities should all be integrated in the design stage.

6.4.3.2 Squares

Public squares and other important urban spaces are important focal areas for urban design and the nightscape. Those areas used for purposes such as gathering, walking, entertaining, eating-drinking, shopping, and exhibiting have to be illuminated in an attractive manner. Not only does the lighting have visual importance but also the lighting elements must harmonize with the overall visual environment and, in this regard, the design properties of the space should help form the basic criteria of the lighting design. In the case of squares surrounded by buildings and illuminated facades, the luminous shop windows of the lower floors will add to the definition and the lighting of the squares. Some larger squares can obtain a strongly dimensioned effect with the help of lighting elements. However, such lighting should avoid light pollution.

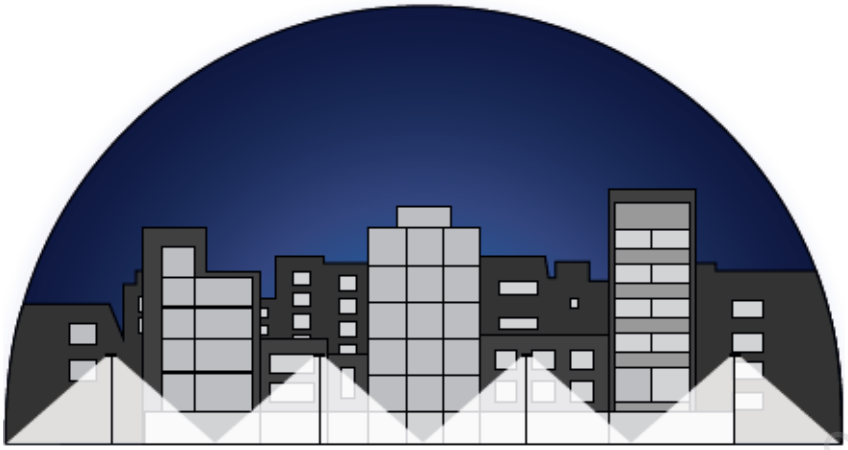
6.4.4 Indoor lighting

The central areas of many cities are characterized by high-rise buildings, which frequently are glass clad and therefore translucent to varying degrees. The interior lighting of such buildings can be said to become a substantial element of their external night-time expression. When large numbers of such buildings predominate in a city centre, their interior lighting becomes a critical component in the overall nightscape. It is however not possible, or desirable from an energy viewpoint, to maintain full-scale interior lighting in commercial premises after business hours. Therefore, the lighting masterplanner should take into account this lighting element but

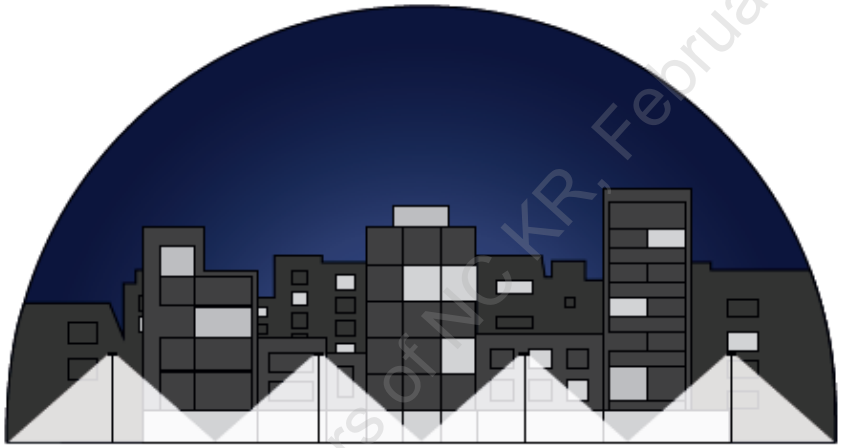
acknowledge that the lit character of the city will change as the evening progresses and commercial lighting is extinguished. This may mean that additional forms of building lighting are desirable such as roof cap lighting or limited facade lighting.

It should also be noted that in smaller scale circumstances, in towns or in residential city areas, the role of residential lighting should not be overlooked as a valuable contribution to the sense of the lit city during the earlier hours of darkness.

As noted, many modern buildings have been designed with glass curtain walls to reveal an overall illuminated structure by night. The interior lighting in such situations relates to the size and shape of the building, the colour of the interior decoration, and the colour and type of lamps and luminaires. Figure 16a shows illuminated windows in the evening. Figure 16b shows shop window lighting at night time. Shop window lighting is a type of advertisement that can make a significant addition to the urban nightscape (good or bad). This is especially true where the shop windows are within a retail centre and adjacent to major pedestrian areas. In such cases, they should be attractively lit, not only for their commercial use but also to help enhance the wider urban nightscape. The indirect effect of the lighting of the pastry shops, the restaurants, the teahouses on the first floors of buildings can also have an important place in urban lighting and increase the luminance of the environment by their appearance. As seen in Figure 16c, it is proper to turn off all the lights while leaving only road lighting in terms of effective energy use for safety and security at late night time (Serefhanoglu Sozen et al., 2005).



a) Illuminated windows in the evening



b) Shop windows lighting at night time

c) Only road lighting at late night time

Figure 16 (a,b,c) – Indoor lighting effect at nighttime
(Figures provided by Serefhanoglu Sozen, Baskan, Tasdelen)

6.4.5 Advertising and sign elements

Advertising elements, which have effectively become a type of urban furniture, should be examined and evaluated in the urban design context. Urban furniture on one hand can functionally serve a city; on the other hand, it can contribute aesthetically. Advertising elements have various configurations within the city. These are generally

- located on buildings (facades, roofs, sometimes as part of the original building design, sometimes as an addition);
- adjacent to roads or squares;
- three dimensional advertising elements (cylindrical, spherical, prismatic or pyramidal);
- part of other urban furniture (bus stops, overhead gantry systems);
- mounted on vehicles.

Advertising elements can be an effective and lively contribution to the central urban scene. In the case of luminous signage, even under day light conditions, high-powered LED or plasma display systems remain visible.

Illuminated advertising signs and other luminous structures can, if well managed, be attractive elements within the nightscape. However, badly lit or excessively bright advertising can create serious visual imbalances, in that the luminance of luminous signs is frequently retained at daylight settings during hours of darkness and therefore cannot only become disproportionately predominant but can also cause glare and serious distraction to drivers, especially when the light is dynamic (flashing lights, videos).

The usage and brightness of such signs should be controlled by the local authority. Within the relevant environmental zone, maximum luminance values have been determined for different sizes of signs. Table 6 shows recommended average luminance values for advertising sign systems (adapted from IESNA, 2009; Gecioglu & Serefhanoglu Sozen, 2007; CIBSE/ILE, 1995).

Table 6 — Recommended values of average surface luminance for lighting of signage

	Environmental zones			
	E1	E2	E3	E4
Sign average luminance L_s (taken as the product of the design average illuminance and reflectance divided by π, or for self-luminous signs its average luminance)	50 cd·m^{-2}	400 cd·m^{-2}	800 cd·m^{-2}	1000 cd·m^{-2}

6.4.6 Media façades

In recent years, another luminous activity in urban areas is the use of building façades as a communication tool. These types of commercial and artistic applications on overall building façades and/or a specific part of them presents generally colourful – dynamic, informing images. It is necessary for the viewers to approach the buildings, or to stand in front of them, or to look at the images on the screens for a long time in order to understand the shown content. Therefore, it is proper considering these types of applications in the concept phase with getting permissions from related establishments in the scope of masterplans. In such applications the following subjects must be taken care of:

- choice of the location;
- convenience of frame rate of display on the media façades;
- determination of the luminance of the screens observing the environmental conditions during day – evening – night times (Table 6);
- not to create inconveniences in terms of traffic (glare, distractions, blocking traffic flow, etc.);
- creating no light pollution;
- considering of energy consumption.

6.4.7 Entertainment and festival lighting

Lighting festivals and entertainment are organized continuously in some cities and at certain periods in others. These 'light shows' are becoming a common event. Such performances, that offer coloured and moving lighting and images, can help increase the attraction of a city and can contribute to the city's image. In some cities where these performances are continuous (such as Las Vegas), these visual effects create a major part of the city's image.

Simpler 'festive' lighting arranged for specific occasions, such as Christmas and New Year's Eve or other festive days, can illuminate temporary tableaux as well as torch lit processions and buildings not normally lit. Depending on the conditions, these activities can be evaluated as a part of the general lighting masterplan.

Coloured, lit, and moving elements always draw people's attention. These elements also have an artistic and creative aspect and therefore people find them interesting. However the risk of becoming repetitive or stale has to be taken into account.

These powerful lighting elements, which affect the city's visual image, should be designed and installed in consideration of the city's overall character, within the urban design context and according to the lighting masterplan. They should also be considered from the point of view of energy usage.

6.4.8 Light art and light festivals

Development of LEDs in the 21st century and providing many opportunities in applications ensure use of LEDs in urban lighting and also benefit of light as an art element. According to the scenarios prepared for specific days and/or periods, opportunities of LED technology and generally colourful and dynamic visual effects obtained by artistic creativity, qualified as "**light art**" sometimes adding also music, creates different attraction areas in the cities.

In this context, in many cities, activities are organized under the name of "**light festivals**", gathering native and foreign people (city users and tourists) with the purpose of social, cultural, and artistic entertainment. Such light festivals are organized, for example, in Berlin, London, Ghent, Amsterdam, Lyon, Moscow.

Light art, light festival and light show activities should be arranged with respect to all interested parties and taking into account

- urban identity;
- choice of location – zone;
- timing of the event;
- environmental conditions;
- traffic conditions;
- light pollution;
- energy consumption, etc.

Besides, ornamentation (show) with light on the façades of individual – public single buildings should be checked likewise according to the items mentioned above.

7 Financial and operational considerations – implementation stage

One of the important aspects of a lighting masterplan is to predict the overall cost of the proposed lighting installations. This invariably becomes a key question in political terms and is frequently seen as one half of an equation in which the other half is the return on investment. Whilst the financial 'return' can often be realized as indirect and can be in the form of an enhanced branding of the city, and any of the positive attributes that arise from this, the fact remains that because costs are substantial they require to be identified in advance. Failure to do so at the masterplanning stage is likely to result in a failure to implement the lighting installations, because both public and private sector decision makers will be unwilling to consider the advancement of an overall lighting programme which has unknown costs.

Since the lighting masterplan is not a document that concerns itself with the detailed design of each and every installation, it is not possible to accurately predict the capital or other costs for each one. Rather, the experience of the masterplanner, coupled with consideration of local market conditions, will become the basis of the preparation of a guideline level of cost prediction. Whilst this approach will inevitably result in varying degrees of accuracy, and comprehensiveness, in respect to individual installations, it will provide the necessary indication of the total quantum of investment which is likely to be required to realize the aims of the masterplan.

It is also possible that decision makers will seek predictions of not only the investment costs but also the likely returns on investment. Whilst this is an understandable response from those who are the custodians of public funds or shareholders' interests, it should made clear that whilst costs can be predicted with a reasonable degree of accuracy, which increases as each installation goes through a detailed design process, the return on investment is less easy to predict. This is because such returns take both the form of 'hard' measurable financial returns and those that are 'soft'. The 'hard' returns can include increased visitor numbers to the city, the sale of a greater number of bed/nights for local hotels, increased 'footfall' in key tourist precincts, associated increased expenditure in retail and hospitality outlets and, perhaps, increased attendances at conferences and trade fairs. In order to predict and evaluate these benefits, it is desirable to introduce the services of an economist with experience of tourism and promotion of a city. Such an economist will wish to consider precedents established in other cities and may also suggest that trial projects be carried out in selected precincts to evaluate the likely wider patterns of return on investment.

The 'soft' returns include the long-term enhancement of the image of the city as a whole, its ability to attract and retain investment through its status as a 'liveable city'. An investment into the night-time image of city through lighting is a reflection of the regard and care which its citizens and politicians feel for it. A city that demonstrates pride in itself, partially through its night-time image, is likely to be found attractive in many other ways.

Cost predictions should include both capital and operational costs:

7.1 Capital costs

Capital cost variables depend on the scale of the lighting master plan, its content, perceived importance and the likely number of individual lighting installations. If the city as a whole, or precincts under consideration, comprise a wide area, or are the centrepiece of a prestigious region and if the subjects to be illuminated are numerous, capital costs will be substantial. Additionally, it should be recognized that external lighting has a finite life, which, depending on the type of equipment and its precise location, can be considered to be between 10 and 25 years. It may therefore be desirable to amortize the capital costs and to consider these to be

the subject of a rolling investment programme which guarantees the long term sustainability of the city's night-time image (see 7.2 below).

Capital costs include the following:

- design fee for the lighting masterplan;
- local consultation, associated electrical engineering services, obtaining planning consent, supervising the installation process and commissioning the completed installations;
- luminaires, initial lamping, control gear, accessories;
- fixings, columns, posts, etc.;
- equipment protection and enclosures;
- lighting control system(s);
- electrical installation;
- electricity connection;
- if the lighting design for some, or all, of the city lighting is to be the subject of a design competition, awards fees should be factored into the overall cost.

As referred to earlier, the foregoing costs can only be accurately and fully predicted at the stage when an individual installation project is being designed in detail. In the context of the preparation of a lighting masterplan, it is only possible to prepare cost predictions on global basis that incorporates consideration of the elements detailed above. This work can only be reliably carried out by a lighting planner with considerable experience of the design and costs associated with a wide range of installation types.

7.2 Operational costs

As with capital costs, the operational costs of lighting relate to the scale of the lighting masterplan and its context. Additionally, operational costs will vary according to the number of hours during which the installation is in operation and the cost of electrical power. The following are the principal issues that determine operational costs:

- the price of electrical power;
- lamp replacement;
- routine maintenance, cleaning, repairs, repainting, inspection;
- management, transport, access plant and overhead charges;
- lighting system monitoring, in the case of large, wide area, installations;
- insurance;
- removal, storage and re-erection of equipment (in the case of temporary or seasonal installation).

It is convenient, when comparing the economics of alternative lighting systems, to assess all costs on an annual basis. Capital costs may be expressed as annual costs based on expected life of the installation and the amortization charges of the principal. Most operating costs are incurred annually. Some types of lamps are replaced once every two or three years, for which the appropriate proportion of their replacement costs can be allocated to the charges for the year. A simple comparison between the annual costs of different systems is obtained by adding the yearly amortization charge to the operating cost. In comparing alternative lamp and luminaire combinations for architectural lighting it can be useful to evaluate, as the common base, the total annual cost per thousand beam lumens, rather than repeatedly working out complete designs to satisfy illuminance and uniformity requirements. There are considerable differences in the periods of time during which different types of exterior installations are in use. As an example, typical hours of use are given in Table 7. If an installation is likely to be operated for only a short time, it may cost less to hire equipment

from a contractor or manufacturer than to buy it (Serefhanoglu Sozen et al., 2005; CIBSE/ILE, 1995).

Table 7 — Example of annual use of lighting installation

Type of installation	Days/Year	Ave. Hours/Day	Hours/Year
Utility lighting (Roads, squares, parks...)			
Dusk to dawn	365	11	~4 000
Dusk to midnight	365	6	~2 200
Architectural lighting			
All year, all night	365	11	~4 000
All year, part night	365	6	~2 200
Seasonal (summer night)	150	9	~900 - 1350
Weekend/Special days...	125	6-9	~750 - 1125

7.2.1 Maintenance

In addition to the normal requirements for the general maintenance of any items of street furniture, the following are specific to lamps and luminaires and should be noted in the lighting masterplan.

7.2.1.1 Decrease in luminous efficacy of lamps

Every type of lamp has a nominal life stated by its manufacturer. Towards the end of this life, a loss of light output and efficacy occurs. At this stage the lamp should be replaced and not be operated to the point at which it fails totally. In the case of an installation comprising a large number of identical lamps, consideration should be given to the recommendation that these be replaced on a bulk, rather than on an individual, basis. This approach is generally more economic in terms of management, manpower and access arrangements, but can also create the problem of leaving an early lamp failure un-replaced for a lengthy period. If the light from this lamp is critical in the overall visual composition of the nightscape, or an element of it, it will be necessary to replace the lamp ‘out of cycle’.

7.2.1.2 Decrease in light output of luminaires

Depending on environmental conditions, the light output from a luminaire together with its optical characteristics can decrease and change because of dust and dirt accumulation on lenses and reflectors. Such accumulation will be largely external but, depending on the design and construction of the luminaire and its Ingress Protection (IP) rating, accumulation of dirt and/or moisture film can also accumulate internally. A lighting installation that is not adequately maintained and cleaned will rapidly deteriorate in terms of light output and precision of distribution.

The issues of both lamp replacement and luminaire maintenance are a major aspect of the responsibility of the city lighting management team and a lighting masterplan should not only emphasize this but also recommend the most suitable management method for ensuring the long-term efficiency of the installations. Failure to include a ‘legacy plan’ within the masterplan will result in progressive deterioration of lighting across the city, with a resultant diminishment of public and political support for the principles laid out in the masterplan.

See also CIE publication 154:2003 *The Maintenance of Outdoor Lighting Systems* (CIE, 2003).

7.2.2 Energy

In most situations, the largest single operating cost is that of electrical energy. Assuming that individual installations are based on the most energy efficient design, energy costs can be further determined by:

- the implementation of a lighting operation policy;
- the use of lighting control systems.

7.2.2.1 Lighting operation policy

A lighting masterplan will differentiate lighting operation policies between those relating to utility lighting and those relating to architectural lighting elements. Most utility lighting will be required to operate throughout the night, some might be switched off when not required and some might be operated on an on-demand basis through sensor systems that monitor vehicular and pedestrian traffic. The use of luminaires with LED light sources can be programmed easily to operate at multiple output levels in order to maximize energy savings by providing lower levels of lighting at times when there is little or no activity on the street.

In comparison with utility lighting, architectural lighting should be switched off after a specific hour at night, possibly according to the seasons and the characteristics of the city and, perhaps, the nation. Limited usage is important not only for energy saving but also to help emphasize the natural differences between day and night (see Table 7). Equally importantly, lighting can help to characterize the difference between summer and winter conditions. For example, in winter it may be desirable to switch off the architectural lighting earlier, since the sun sets earlier and climatic conditions are less favourable for late evening sightseeing, whilst in summer, or in warmer climates, a later switching off time may be more desirable.

Under certain circumstances it may be desirable to limit the occasions when individual buildings are illuminated. Illumination might be linked either to the building's use and status, or maybe to a historic anniversary or festival. For whatever reason, it is important that the masterplan takes into account the need to consider variable operational times of lighting as part of the overall presentation and image of the city at night. An additional consideration is that if a building is of fundamental importance to the composition of the overall nightscape, it might be subject to differing levels of control programming; a simple level for the majority of times and a more complex presentation for special occasions. The use of LED-driven solid-state lighting provides particularly good opportunities to create a multi-programme approach.

7.2.2.2 Lighting control systems

For most utility lighting installations, an automatic switching system should be used and can comprise individually, or in combination:

- local or group time of day and calendar controlled switching,
- local photocell activation,
- motion sensors for local groups,
- recorded programming for group operation,
- telemetry systems for control of wide area road and street lighting.

A lighting control system also allows monitoring, reporting and remote maintenance tasks.

Whilst it is less important for architectural lighting to be so controlled, it is obviously desirable if this can be automated to the greatest possible extent. The prescription of such control systems should form part of the masterplan, with fully automated, programmable, systems being specified to control the entire city and its precincts. The architecture of such systems should be determined only after the overall architectural lighting infrastructure has been

defined and the macro control groups, sub groups and operational diversities have been identified.

7.3 City lighting management

The long term, sustained, success of a planned lighting approach is wholly dependent on the management of:

- the lighting planning process,
- the relationship between public and private interests and property ownership,
- the operational control of the lighting,
- the maintenance of the lighting,
- the lighting budget.

7.3.1 The lighting planning process

It is essential that individual lighting initiatives are planned in accordance with the principles of the lighting masterplan. This means that there is a requirement for the city to establish a system that reviews and approves lighting plans for each installation. Additionally, the city will require the system to extend to the monitoring of installations to ensure that these are completed in accordance with the approved plans and are correctly commissioned in terms of aiming and focussing of equipment as well as the programming of the control system.

This, and all other aspects of the management of the architectural lighting, can be carried out as an extension of the responsibility of an existing planning department or by a city lighting management group that either exists, often as the department responsible for road and street lighting, or by a newly formed city lighting management team.

7.3.2 The relationship between the public and private interests and property ownership

Since buildings, and other elements which require to be lit as part of the total nightscape, are normally both publicly and privately owned, it is important that successful cooperation and participation be established across both sectors. In practice this means that during the development of the lighting masterplan it will be necessary to create a political momentum which encourages participation in the lighting implementation programme both from relevant departments within the city government and from the wide range of private building ownership structures. Additionally it may be necessary to consider a programme of incentives to encourage the private sector to participate. This can take the form of public subsidy of design and/or installation costs or financial assistance in meeting the costs of operation. The objective should be to secure the participation of private owners of buildings that form an important component in the composition of the city's nightscape and to retain a commitment to the long-term operation of their lighting.

7.3.3 Developing the lighting budget

The capital and operational costs of urban utility lighting is normally the responsibility of the city and, possibly, regional government. The funding of such lighting invariably comes from the public purse but the same cannot be said for the funding of architectural and environmental external lighting.

The question of paying for what can be termed 'elective' lighting can become contentious and rests on the perceived value that such lighting contributes to the night-time economy in direct and indirect terms. There can be reluctance, particularly on the part of the private sector, to contribute to the common good of the city, particularly if the private owners of key buildings do not consider there to be any commercial value in lighting them.

Inevitably, the development of a detailed lighting budget, inclusive of capital and operational costs, must become the foundation for both the negotiated participation of the private sector and the securing of public funding over a long-term period. Only when costs have been predicted as accurately as possible does it become possible to engage in realistic discussion about investment into lighting and what the mix of public to private funding needs to be. The initial planning of the lighting budget should be carried out based on what should ideally be lit and not based on what can be lit from a financial perspective.

Experience suggests that 'seeing is believing' and that the persuasive power of viewing successful urban lighting is significant. Accordingly, there is value in project leaders and investors making visits to cities which have a well-established urban lighting programme and discussing the merits of urban architectural lighting with local politicians, private building owners and community groups. Additionally, discussion with city-lighting managers, economic advisers and local business forums can provide evidence which encourages and supports investment into elective lighting.

A consideration in the funding programme is the inclusion of sponsorship to meet some or all of the costs of installation and operation. Lighting is an intrinsically public activity and gains high levels of exposure, which can provide an attractive marketing opportunity to a sponsor.

7.4 Planning for lighting implementation

In reality it is neither possible not desirable to light all the elements of the city which are identified in the lighting masterplan as one large project. The likelihood is that publically owned buildings and structures will become the initial lighting implementation projects and thereby set a visual benchmark, which both encourages the participation of the private sector and establishes a quality norm.

In view of this reality, it is desirable that the lighting masterplan includes a prioritized implementation programme with milestone dates for the completion of the lighting of the key visual anchors. Additionally, a subsidiary programme should be drawn up for the implementation of the lighting to secondary buildings and structures. Whilst the masterplan will have identified the majority of elements to be lit, the implementation programme will inevitably reveal gaps in the programme and these additional elements should be added to the overall project.

Most cities that have adopted a lighting programme, based on a masterplan, have experienced an implementation programme measured in years. Availability of funding, gaining planning approval and the participation of the private sector are inherently long-term issues and it should therefore be accepted that the development of the lit city can be a gradual process.

Annex A

Table A.1 — Example of basic criteria for choosing historical buildings and other structures (Serefhanoglu Sozen, 2007)

Subjects	Function	Historical meaning	Appearances	Image quality	Symbolic quality	Architectural properties	Silhouette effect	Distances	Promotional effect	Total points
Historical buildings	10	10	10	10	10	10	10	10	10	90
Blue Mosque	10	10	10	10	10	10	10	10	10	90
Hagia Sophia	10	10	10	10	10	10	10	10	10	90
Yeni Mosque	10	10	10	10	10	10	10	10	10	90
Firuz Ağa M.	10	10	10	10	10	10	5	10	10	85
Nur-u Osmaniye	9	10	9	9	9	10	10	8	10	84
Beyazit M.	10	10	9	8	9	9	9	8	9	81
Şehzade M.	9	9	9	9	9	9	9	9	9	81
Rüstem Paşa	9	8	10	9	8	9	9	9	9	80
K.Ayasofia M.	9	9	9	8	8	9	9	9	8	78
Arpacılar M.	9	9	9	8	9	7	9	9	8	77
Structures	10	10	10	10	10	10	10	10	10	90
Beyazit Tower	9	9	9	9	8	9	9	9	9	80
Istanbul Walls	9	10	10	10	10	8	10	10	10	87
Bozdoğan A.	9	10	10	10	10	9	10	9	9	86
Egyptian Obelisk	9	10	9	9	9	10	7	7	8	78
Serpent Column	9	10	9	9	9	9	7	7	8	77
Walled Obelisk	9	10	9	9	9	9	7	7	8	77

Table A.2 — Example of basic criteria for choosing historical buildings and other structures (provided by Gasparovsky)

Subjects	Function	Historical meaning	Appearances	Image quality	Symbolic quality	Architectural properties	Silhouette effect	Distances	Promotional effect	Total points
Historical buildings	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**90**
Bratislava Castle	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**90**
St. Martin's Cathedral	**10**	**10**	**10**	**9**	**9**	**9**	**10**	**10**	**10**	**87**
Presidential Palace	**10**	**9**	**9**	**10**	**9**	**10**	**7**	**7**	**10**	**81**
Slovak National Theatre	**9**	**9**	**9**	**10**	**9**	**10**	**7**	**7**	**10**	**80**
City Hall	**9**	**9**	**9**	**10**	**9**	**10**	**7**	**6**	**10**	**79**
Slovak Radio	**9**	**6**	**7**	**10**	**10**	**10**	**8**	**9**	**10**	**79**
Zichy's Palace	**9**	**9**	**8**	**9**	**9**	**9**	**4**	**5**	**9**	**71**
Structures	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**90**
The UFO Tower	**10**	**8**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**88**
Slavin Memorial	**10**	**8**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**88**
TV Tower Kamzik	**10**	**8**	**10**	**10**	**9**	**10**	**10**	**10**	**10**	**87**
Gen. M. R. Stefanik Statue	**8**	**7**	**6**	**9**	**10**	**9**	**7**	**8**	**10**	**74**
Svatopluk statue	**8**	**4**	**7**	**9**	**10**	**9**	**6**	**6**	**10**	**69**

As seen in Table A.1 and Table A.2, the objects with total points above the threshold should be illuminated first. For example; as seen in the tables, the objects that have 80 points and more can be illuminated first. The objects that have less points can be illuminated later.

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