An Analytical Approach to The Urban Outdoor Lighting Quality of Residential Areas in İzmir

By

Rabia Çam

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We approve the thesis of **Rabia ÇAM**

Date of Signature

--- 23.01.2004

Assist. Prof. Dr. Erkal Serim

Supervisor

Department of City and Regional Planning

--- 23.01.2004

Assoc. Prof. Dr. Güneş Gür

Co-Supervisor

Department of City and Regional Planning

--- 23.01.2004

Assist. Prof. Dr. Murat Günaydın

Department of Architecture

-- 23.01.2004

Assist. Prof. Dr. Nicel Saygın

Department of City and Regional Planning

-- 23.01.2004

Assoc. Prof. Dr. Güneş Gür

Head of Department

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ABSTRACT

The major aim of this study is to present a critical look on the existing outdoor lighting installations and put forward a comparative approach to assess the quality of outdoor lighting systems in the selected multi-family residential areas. This aim is based on a common assumption that the existing lighting system standards and installation arrangements are unsatisfactory. Upon considering the urban context, it can be stated that residential areas particularly are lack of well-illuminated public spaces. In this respect, this study aims to determine the common illumination problems that affect night-time outdoor space quality in residential areas and these factors behind this problems.

The data and material necessary to carry out this study are obtained from literature survey and site survey. The collected data are evaluated through Cost Analysis and Analytical Hierarchy Process (AHP) used by Expert Choice Software. AHP has been used for the determination of priorities, evaluation of the outdoor lighting quality for the residential areas and selection of the best one in the selected residential areas that are Mavişehir, Oyak and Evka 3 in İzmir. Analysis indicated that the quality problems about outdoor illumination could be decreased through effective design and regular care and maintenance efforts.

Key words: Lighting Quality, Illumination, Lighting, Outdoor Space Lighting, Light Pollution, Outdoor Space Quality, Analytical Hierarchy Process (AHP), Residential Area

ÖZ

Bu çalışmanın amacı; dış aydınlatma uygulamalarına eleştirel bakış açısı sunmaktadır ve seçilen toplu konut alanlarındaki dış aydınlatma kalitesinin ölçülmesine ve karşılaştırılmasına yönelik bir yaklaşım önermektedir. Bu çalışmanın dayandırıldığı genel kanı, mevcut aydınlatma sistemlerin standartlarının ve uygulamalarının yetersiz olduğudur. Kentsel bağlamda bakıldığında, genellikle konut alanlarının iyi aydınlatılmış kamu alanlarından yoksun olduğunu söyleyebiliriz. Bu çerçeve kapsamında, bu çalışma konut alanlarındaki gece yaşam kalitesini etkileyen mevcut aydınlatma problemlerini ve arkasında yatan faktörleri belirlemeyi amaçlamaktadır.

Bu çalışmayı gerçekleştirmek için gerekli veri ve materyaller arazi ve literatür çalışmalarından elde edilmiştir. Bu veriler Maliyet Analizi ve Analitik Hiyerarşi Süreci ile değerlendirilmiştir. Analitik Hiyerarşi Süreci, Expert Choice bilgisayar program yardımı ile değerlendirilmiştir. Analitik Hiyerarşi Süreci, önceliklerin tespit edilmesi, konut alanlarındaki dış aydınlatma kalitesinin değerlendirilmesi ve belirlenen konut alanları olan Mavişehir, Oyak ve Evka 3 içerisinde en iyi aydınlatma sistemini sergileyen alanın seçilmesi için kullanılmıştır. Analiz çalışması, dış aydınlatmaya ilişkin kalite problemlerinin etkili tasarım ve düzenli bakım çalışmaları ile azaltılabileceğini göstermiştir.

Anahtar Kelimeler: Aydınlatma Kalitesi, Aydınlanma,Aydınlatma, Dış Mekan Aydınlatması, Işık Kirliliği,Dış Mekan Kalitesi, Analitik Hiyerarşi Süreci, Konut Alanı

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INTRODUCTION

1.1. Definition of The Problem

Lighting is an important aspect of urban life as illumination of building and the public realm has the potential to enhance the urban fabric and the quality of life in the urban areas. Outdoor lighting system improves the quality, consistency and efficiency of night lighting in streets and other outdoor spaces.

Recently, there has been an increasing public awareness about the quality of public life in the cities of both developed and developing countries. Urban places need to be rehabilitated because of increasing urban quality problems such as lack of orientation, or poor living conditions and social life. Therefore, with the aim to achieve quality in the public realm, local authorities or public and private organizations apply urban renewal projects and initiatives on street furniture. Outdoor lighting has an attractive role as a key component in these projects. It refers to illumination of certain activity and public spaces, and the lighting fixtures are involved in both streetscape design and part of urban infrastructure system. These fixtures can be seen both day and night, and their appearance influences the urban design positively. Moreover, good lighting adds an atmosphere, an ambiance, and a character to the body of the city. Briefly, outdoor lighting may:

- enhance perceptions of urban form,
- integrate with the form and character of spaces,
- promote the appearance of spaces or objects.
- defines a circulation pattern
- emphasize aesthetic features
- contribute to the attractiveness of the space.
- provide a coordinated and uniform lighting system
- select fixtures and proposal system for minimizing operational maintenance and repair.

While well-designed outdoor lighting system enriches the aesthetic quality of the environment and at the same time minimizes energy use and operating costs, it also provides necessary illumination, attraction, safety and security. Consequently, outdoor lighting today represents a challenge and opportunity for cities such as creativeness, quality, and beautification.

Beside the positive benefits of nighttime lighting, there are many problems for existing lighting practice. Outdoor lighting is not a well-considered issue in Turkish cities; as a consequence, existing lighting applications assist quality problems in both streetscape and infrastructure design element. Moreover, these do not provide high quality environment and visual demands at night-time.

The majority of those who concerned with outdoor lighting declared that "lighting in itself is not a problem; it only becomes a problem where it is excessive, poorly designed or badly installed. Inappropriately designed outdoor lighting applications in both rural and urban areas can result light pollution, inefficiency in lighting and degradation of visual image." (Dept. E&T&R, 2.4, p.12) If outdoor lighting is not well-designed and properly installed, it may be inefficient and may cause unsafety in the nighttime environment. The urban outdoor lighting installations are based on two main concepts that are streetscape problems and engineering problems. To sum up, the illumination system problems may stem from the following:

- Local authorities related with electricity are not experienced in the science of outdoor lighting. Until recently, engineers appointed in local municipalities were not obliged to be experts in outdoor lighting. However, today's electricity authorities must be responsible for setting appropriate lighting standards. It may be said that "low quality night-time environment may be caused by the mentality of local authorities and economic restrictions"
- Local plans do not include information related to lighting. Existing systems have inappropriate applications in the built environment. As the demands for lighting undoubtedly continue to rise a comprehensive review of the issues related outdoor lighting could be needed.

- Outdoor lighting system is a specialized system not only for urban planning and design discipline but also many others. Generally, in outdoor lighting projects, the budget required for improving aesthetic and functional quality of streetscape design is considered to be unworthy of spending on, and so this spending tends to be kept to a minimum. This attitude displays a poor understanding of urban design. In fact, a highly effective, urban design practice may be achieved through a cost-effective and economic approach.

In the Turkish case, the problems related to outdoor lighting cover improper illumination designs and lighting installations as well as total absence of lighting. Roadway and public areas are better illuminated while particularly residential areas suffer from many illumination problems. Except for a few locations; residential areas have no illumination strategies in comparison to roads and public plazas constructed by İzmir Greater City Municipality (İBŞB), other local municipalities in İzmir metropolitan area and TEDAŞ. Thus, the main problem is that "the existing lighting standards and installation organizations are unsatisfactory".

1.2. The Aim of the Study

In this study, the major aim is to present a critical look on the outdoor lighting installation phenomenon and put forward a comparative approach to assess the quality of outdoor lighting systems in the selected multi-family residential areas. It focuses on determination of the common illumination problems that affect night-time quality in residential areas and the factors behind these problems. Based on the existing outdoor space quality problems at night-time, the study thus attempts to identify good practices and effective lighting principles that balance cost effectiveness with the outdoor lighting quality.

This study also includes detailed examination and evaluation of the ordinances, regulations and common lighting concepts. Furthermore, this study additionally intends to provide a guideline for designing future public and private lighting projects.

The study reveals with the evaluation of residential areas with outdoor lighting quality. The research focuses on determination and evaluation lighting quality in Mavişehir, Oyak, and Evka 3 multi- family residential areas are determined as the case study for the research. This study also includes data and material about common lighting problems and evaluations for multi family residential district

It is accentuated that design of illumination should be suitable for all people. Equality is a general term that may be an approach providing the best illumination and good illuminated areas. Thus, this study concentrates on how outdoor lighting schemes should be improved toward carrying out with a coordinated system that is attractive, functional and energy efficient, especially in residential areas.

1.3. Methodology

The method of this study is based on three types of analyses as theoretical, empirical and comparative analysis.

1. **Theoretical Analysis**: The theoretical framework of the study includes literature survey about technical data, light pollution, design issues and constraints, basic principles of lighting design and outdoor regulations.
2. **Emprical Analysis**: Assessments of the quality of urban environment are most appropriately based on humans' evaluations of the positive and negative expressions of their experiences in the social and physical realms of their urban environments. In a similar approach, assessment of the quality of outdoor lighting is based on humans' evaluations and evaluations based on quantitative findings. This is because quality of outdoor lighting is as important as quantity of ones. However the measurement of quality is more difficult than quantity.

   This study defines the existing lighting practice in İzmir and includes a review of recent planning applications in multi-family residential areas and appeals the involved outdoor lighting. Mavişehir, Oyak and Evka 3 are chosen as the multifamily residential areas which accommodate different income groups and are under responsibility of different municipalities. Assessment quality of lighting plans primarily need the determination of existing situation in respect to specific lighting standards and recommendations, cost benefit analysis and spatial factors where appropriate. In addition, after the literature survey, the empirical analysis includes field survey, adequacy analysis and cost analysis that are applied in the selected residential areas. These are;

- **Field survey** includes existing information that is written and mapped information about existing lighting fixtures and physical environmental activities. In urban environment, the data based on the location, type, physical condition, equipment characteristics are determined in the selected residential areas. Moreover, for functions and activities, the existing system is observed in terms of efficiency, adequacy, installation organization, character, and level of illumination.

- **Adequacy analysis** identifies shortages in terms of type, location and conditions of existing light fixtures. According to different land uses and activities, inadequate and excessive lighting levels are measured by lux-meter.
- **Cost analysis** defines the sample areas of costs, including initial, operational, maintenance and energy costs. The financial values are calculated with the total lighting cost sheet adapted from the "Outdoor Lighting Pattern Book", published by the Lighting Research Center, and an article with the title called "A Simple Cost Estimation Technique for Improving The Appearance and Security of Outdoor Lighting", published by Russel P. Leslie. (Russel&Lesslie, 1996) The equipment unit prices are obtained from "2003 Elektrik Proje and Tesis Birim Fiyat Kitabı", published by TEDAŞ and several manufacturers. All costs are based on 2003 TL and also in November 2003 dollars.
- **Interviews:** The questionnaires is used to determine weights of factors and evaluate the opinions of the residents and the local professionals about the outdoor lighting quality. The results of surveys and cost analysis have been used to determine the priorities and to compare the illumination designs of the selected residential areas.

3. **Comparative analysis:** this analysis is carried out to assess the quality of illumination in the selected residential areas. This step includes interpretation of the surveys, design concepts and cost analysis. The Analytical Hierarchy Process model (AHP), developed by Thomas Saaty, (1989) that is multi-attribute decision analysis

is used for development of an assessment of the outdoor lighting quality by using residential areas in İzmir. It is important in this context which is a decision to support the approach for the determination of the multi criteria factors at certain conditions. The aim is to measure the outdoor lighting quality in residential areas to systemize the evaluations for the results of surveys of the sample areas. Results of the field surveys and cost coefficients have been used for comparison of the outdoor lighting quality of selected areas. These are evaluated by using Expert Choice Software.

1.4. Organization of Thesis

This study has been structured on five chapters. The first part of the research gives general information, including problem definition, aims of the study, methodology and thesis organization.

Chapter 2 mentions relations between lighting need, urban design and urban infrastructure. Also, this chapter looks at effective lighting design and its principles. This is based on theoretical data. According to theoretical data, this section explains lighting terminology and its basic equipments, design procedures and describes how the impacts of a lighting schemes ought to. In short, this chapter is formed as a database to be used in analysis and determine the existing conditions.

Chapter 3 explains lighting needs in every scale. As well as giving guidance to local authority planners, urban designers and engineers, this section is intended to outline good practice to prepare a new or redesign lighting scheme concerning land use designation and urban design policies. In this respect outdoor lighting regulations and standards are examined to provide effective designs in lighting practice.

Chapter 4 is related with the description of the selected areas and its lighting design concepts, the analysis methods and its principles have been examined to describe and evaluate of outdoor lighting quality. After the observations on existing lighting quality in İzmir, this research has been structured on the outdoor lighting installations in residential areas. Detailed field surveys have been carried out for each selected residential areas with measured illuminance levels by luxmeter. According to determined existing design concept, performance criteria, the existing illumination systems have been evaluated and calculated the cost issues, including initial, operating, installation and energy costs. At the end of these steps, the selected areas have been compared with using Analytical Hierarchy Process. In short, the selected multi-family residential areas are analyzed to assess the best quality of outdoor lighting design between the residential areas.

The last chapter summarizes the roles of lighting and reasons of urban illumination problems in terms of quality of life at night-time. In conclusion, this study ends up with the results of evaluation for the study and this research also suggest a starting point for the further studies related with urban illumination.

CHAPTER 2
CONCEPTUAL FRAMEWORK OF THE STUDY

2.1. Outdoor Lighting in Urban Design

Cities as dynamic living organisms have their identities. In the complex dynamism of today's living, cities' identities can easily become better or worse. Identity of a city is the characteristics of the natural, social and the man- made environments that are all connected.

In Rapoport's words, "Cities are designed to meet, people's environmental preferences and notions of environmental quality. The processes that create urban environments are complex and the search for quality of urban design seems to run in a circle. Society seeks improved quality" (Rapoport 1977, p.49). Over years, there have been different opinions of urban designers about what constitutes urban quality or the sense of place. In his later work Lynch (1981) wrote the qualities which urban design should seek to achieve, and so create a sense of place, while Alexander (1979) writes of the 'quality without a name', which he defines in terms of the recurring and interlocking patterns of events (and, no doubt, meaning) in buildings, spaces and places. (Montgomery 1998, p.102) Lynch offers five basic dimensions of city performance: vitality- sense- fit- access and control. He points out "a vital city is the one that successfully fulfils the needs of its inhabitants within a safe environment- in other words; a good city allows maximum scope for activity". (Lynch 1960) To sum up, the processes that create urban environments are complex and the search for quality of urban design seems to run in a circle.

Michael Parfect and Gordon Power suggest that "the essential of quality in urban environments is not something that can be readily measured, or even identified fully, as it may well spring from a combination of factors relating to "sense of place………" Parfect & Gordon 1997, p.135) They argue that the elusive element of 'quality is vital in a strong emotional link between people and built environment.

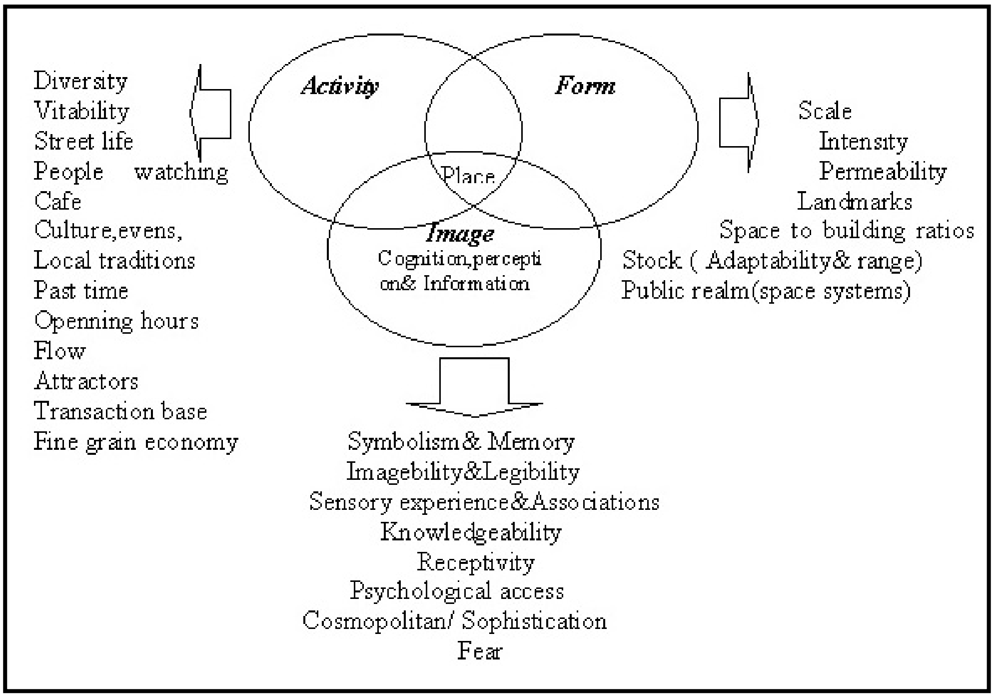

Figure 2.1 Policy directions to foster an urban sense of place (Montgomery 1998, p.98)

Niger Taylor (1999) also points out that "...successful urban design generally involves successful combination of these materials. It is in sense that good urban design requires an understanding of the raw materials of urban design. The raw materials of urban design are simultaneously the raw elements of urban design which make up streetscapes." (Taylor 1999, p.207-208). The quality and image of the city in the public perception is created by the cohesiveness of the public domain – the facades, squares, streets, open spaces, etc. – together with the "furniture" contained within their structure planting, seating, lighting, signage, paving, etc. The primary objective of urban furniture is to provide services to the citizen that uses the urban space. (Dublin Corporation p. 15)

Urban furniture provides urban comfort and aesthetic appeal while also provides an increase in the pleasures of urban life. In order to achieve this, the most important quality required for the features and placement of urban furniture must be harmony. (Yıldızcı 2001, p.35) In the creation of city identity, urban furniture has an important place; for instance, "in the Southern France, in Cate d'Azur, Canner, Nice and other cities the urban furniture has a corporate identity of that area. The examples can be extended like London telephone cabins and streetlights. In Barcelona and in Lisbon pedestrian side walks and street lamp characterize the identity of the city and become the symbol. In Barcelona for the purpose of Olympic Games, a set of urban furniture is located in popular Ramblas to give a distinguished vision to the city. In San Francisco, newsstands, street lamps and street toilets are considered in harmony." (Bayazıt 2001, p.17) Moreover, urban furniture also reflects the environmental characteristics other than responding to modern day requirements.

In this respect, the qualities and organization of both outdoor spaces and urban furniture have a huge importance to form urban identification and give character and life to outdoor spaces. Urban furniture is the collective term for pieces of equipment installed in the street, such as street lighting, traffic signs, and garbage boxes.

Urban furniture consists of man-made elements of a streetscape located on the sidewalk, on a plaza, or in another type of pedestrian area. Urban furniture elements generally associated with amenities for pedestrians, and may be free standing or fixed. Urban furniture includes different elements with different characteristics. Also, urban furniture can be classified according to different points of view.

Yıldız classifies urban furniture according to their types, as follows:

- Surface paves (Concrete, Stone, Wooden, Asphalt, Brick...etc.)
- Seating Units (Benches, Chairs, Group Seating Elements
- **Lighting Elements (Road and Area lights)**
- Sign and Information Systems (Orientation and Indication elements, Info-Communication Notice Boards)
- Barriers (Dissuasive and Restrictive Elements, Pedestrian and Traffic Barriers etc.)
- Water Elements (Ponds, Temples, Water Spouts, Channels, and Fire taps)
- Superstructure Elements (Bus-stops, Shades, Pergolas)
- Commercial Units (Kiosks, Exhibition Nodes, Buffets, etc.)
- Artistic Objects (Statues)
- Other Elements (Flag poles, bins, post boxes, public toilets, flower gardens, ticket machines, bicycle parking areas, clocks, park meters) (Yıldızcı 2001, p.35)

In a similar approach, Hacıhasanoğlu defines a classification according to functions of urban furniture, with two basic functions and some sub-functions.

- Urban furniture according to their functions

  - Urban furniture about service and shopping activities: bus stops, telephone boxes, kiosks, bollards, clocks, city toilets, parking machines, cycle parking
  - Urban furniture aiming sports and entertainment, recreation activities; sculptures, benches, canopy, sculptures, play and sports equipment and some special ones.
  - About communication: traffic and orientation panels, advertisement and information panels, flag pillars

- According to infrastructure and landscape

  - Urban furniture about infrastructure: pavement coverings, **illumination elements**, trash receptacles, covers of infrastructure and sewer system,

  - Urban furniture about landscape: fountains, pools, tree grates, flowerpots, park and green area protection. (Hacıhasanoğlu, 1991, p.5)

Differing from Hacıhasanoğlu and Yıldızcı classifications, Asatekin describes urban furniture in respect to functional typology and its resultant product typology as follows:

- "Transient Use: This refers to the citizen's use of given location of the urban space just for a second or two, i.e. in transition. In this respect, the urban furniture elements that relate to these are paving elements, kerb elements, etc.
- Stationary use: In this mode the citizens use a given location for a certain length of time. The urban furniture elements that relate to these are seating elements (in bus stops, in parks, along the road, etc.), canopy elements (over bus stops, over certain areas of the sidewalk, over pedestrian streets, etc.) kiosks and the like.
- Functional use: This refers to the citizen's needs that have to be answered. In this respect one can refer to information needs, communication needs, and physiological needs. Visual communication needs bring forward several types of location information elements (street names, bus stop names, directional information, etc.) social information elements (posters, clocks, advertisements, etc.), convention information elements (traffic signs, traffic lights, regulation signs, etc) General communication needs are telephone booths, public-address systems, mailboxes, internet kiosks and the like. In case of physiological needs one can refer to drinking fountains, urinals, etc.
- Ancillary use: This refers to the needs that arise while using the elements listed above. The urban furniture elements that one can name in these respect are **lighting elements (lamps of different types**), delineation and safety elements (bollards, railings and barriers along level differences and stairs, property lines, etc.) infrastructure elements like gullies, and spiritual elements like planters, pools, cascades, fountains, sculptures, etc". (Asatekin 2001, p.63)

In recent decades, the concept of urban design has developed and in a close connection with urban furniture. Design of urban spaces must consider the type, size location and materials of the furnishing. The design and detailing and choice of materials of the furnishing are important in terms of continuity, durability and ease of maintenance.

Outdoor lighting is an essential element in respect to urban furniture context as the nighttime element. It is a micro element in urban design. Harold Lewis Malt's definition of lighting element that "lighting elements is a raw material similar to space." (Malt, 1970, p.151) In similar approach, Rapoport explains "the lighting elements as semi fixed elements that are of particular importance in studying meaning in our current element". (Rapoport, 1999, p. 56)

Consequently, the lighting elements affect the urban design quality and urban infrastructure system. An effective design of the outdoor lighting provides both an aesthetic values and functionality. Moreover, a good design ensures an adequate budget for project management. The research for determining the quality of outdoor lighting includes the two main concepts that are urban design and urban infrastructure, as presented in the following sections.

2.1.1 Lighting Elements in Streetscape Design

Outdoor lighting is essential in organizing and defining urban activities. Outdoor lighting can also become part of the "language" of streetscape elements that can add to the legibility of the urban areas; therefore there is a strong relationship between the structure of urban settlement and outdoor lighting. In recent years, probably, there is no element in urban design has developed more than lighting and its concept.

The lighting plan is generally perceived only technical and infrastructure design, however, technological improvements and practical usage design guidelines have been improved through high quality lighting design in outdoor spaces. Therefore, the lighting elements are taken into consideration as common concept that is humanistic approach with technical concept.

The lighting elements are architectural elements, seen both day and night so their appearance and style should support design concept. The selection of outdoor lighting element is important. Lighting equipment varies widely in style, quality and price. In design process, features of fixtures that are using material, size, and model must design in care. A number of factors can contribute towards the selection of cost-effective, good quality equipment.

Figure 2.2. Modern Lighting Fixtures (Source: Siteco 2003, p.207)

Artificial lighting can be provided overhead streetlights, bollards, feature lights, and pedestrian-scale fixtures. The individual and group design of elements and their integrity in an urban design should be achieved in order to appear as a natural part of the streetscape. Lighting elements should be simple in design and modest in size. They should also continue to make compatible with other furniture in design, color and materials.

Tezel and Manav suggest that “both city illumination and urban equipment system can be used as tools to contribute to the aesthetics of landscape as cultural entities”. (Tezel&Manav 2002, p.23) Nowadays, the concept of city beautification mostly has been considered in respect of illumination by developers and city councils. In some cases, an aesthetical aspect of luminaries is also important as a design element. In the city, appearance of these elements is preferred when these are used for city beautification in areas generally used by pedestrians such as green areas, parks. On the contrary, concealing these lighting elements is required in lighting applications that are done for showing a city value. Şerefhanoğlu and Bostancı, who are work on the Istanbul

Lighting Master Plan concerning city beautification concept, defined “the lighting of values that is important for city appearance and aesthetics within the city, except technical lighting that is important for safety and security, takes place in city beautification.” (Şerefhanoğlu & Bostancı 2001, p.263) There are many the studies of lighting master plan in respect to city beautification in the world, in such as Japanese cities, Moscow, Melbourne, Lyon etc.

Rombauts defines that the urban environment around the basics elements “city”, “people” and “light”:

- “Assigning the city a personal and historical identity in time and space;
- Bringing together (the city as a dynamic actor);
- Searching for more (attractive and animating lighting and magic pulses are inviting people to discover the city);
- Connecting the elements (efficient city transport systems);
- Balancing the elements (towards harmony in the urban chaos);
- Fear and hope (concern and excitement)” (Rombauts 2001, p.100)

Consequently, outdoor lighting elements and systems plays an important role in improving urban quality in the city.

2.1.2. Lighting Elements in Urban Infrastructure Design

Apart from urban identity, lighting elements are the important factor for urban infrastructure. Lighting elements must have technical parameters for providing the urban quality. In this point of view, “an efficient lighting design requires efficient lamp technologies, optimum pole placement and efficient fixture photometric (light distribution) while using the least amount of energy and meeting various requirements for visibility and appropriate light levels”. (Nyserda 2002, p.3)

Outdoor lighting is designed to provide light on streets, pedestrian ways, parking lots and green areas. These lighting systems may differ in structure, equipment, calculations and method of control. Moreover, outdoor lighting effectively involves the components that are design, construction, maintenance and energy.

Design of public lighting should meet the requirements and recommendations of these standards. The design and implementation of lighting systems should require a flexible and responsive approach for infrastructure projects. After the design stage, the lighting applications must provide human safety at the implementation stage; for instance, the public lighting utilities have to locate underground. It should be installed with due regard for the fabric of the built environment. The installed lighting system should facilitate maintenance and repair. The quality of the outdoor lighting also depends on the well-planned maintenance program.

Energy for outdoor lighting is the biggest part in the energy usage of a city and the maintenance and operation of the lighting that is a considerable expense for every city. Electric power usage for outdoor lighting are more than the other electricity uses of the city. It is therefore important to allocate resources most efficiently and make use of the technologies available today. The new technologies can be installed on the energy performance. Some of the cities in the world have improvement of outdoor lighting in order to make it correspondent to the standards decreasing consumption of electric energy. The public lighting infrastructure should increase the sustainable energy outcomes through the installation like solar lighting equipments.

Figure 2.3. Solar Lighting Fixtures.
(Source: http://www.solarlighting.com/htmlsite/parklighting.html)

Furthermore, the lighting projects have primarily concerned initial cost in order to influence the urban quality and image. Efficiency, initial cost and other economic concerns should be evaluated to known about direct and indirect benefits. Through the use of efficient technologies and design practices, effective outdoor lighting schemes can be realized. In addition, The Illuminating Engineering Society of North America (IESNA) declares that "the best outdoor lighting practice allows comfortable and safe vision while conserving energy and minimizing environmental adverse effects." (LPAG 1997, http://www.maltastro.org/lpag/guidelines.htm)

Public lighting infrastructure can clearly influence development patterns, general economic environment and quality of life issues. Public lighting infrastructure can be a complex. Consequently, local authorities should be considered improving their public lighting infrastructure.

2.2. Outdoor Lighting Design Issues and Constraints

The designs are established to realize properly the goals for each activity or area. Moreover, before the planning the projects and details, the planners or designers need to understand design issues and constraints. This is because that, they must know how the factors affect the projects and the impacts and effects vary from project to project.

The planner or designers should investigate the impacts of design issues and constraints before design stage. First of all, the planner determines the overall project goals for understanding of the best approach for outdoor lighting installations. Therefore, this section presents design issues and constraints. Design issues and components consist of six components, as follows:

1. **Technical requirements**: Basic lighting performance is based technical components of lighting. These are level of illumination, distribution, color and uniformity that are critical. To achieve efficient design:
    - Select proper lamp and luminaries with full optical controls.
    - Select fixture with high efficiency and proper light distribution
    - Define properly the fixture locations to meet design requirements without light pollution
    - Define the placement of wires underground (Salt 2003, Nyserda 2002)

The technological improvements for outdoor lighting industry have been developed day by day as well as indoor lighting. Especially municipalities and related institutions should follow the improvements and recommendations about outdoor lighting decision. Planners and engineers who are appointed in public institutions should be in contact with the manufacturer in order that make sure the best solutions for the proposed lighting design.

2. **Cost savings**: Cost limitation is often main objective for outdoor lighting schemes. Cost of lighting practice includes initial cost, energy cost, maintenance-repair cost and operating cost. According to CIE, "the need to provide a scheme for a low initial cost is a challenge but should be tackled in a way that produces a cost-effective solution. The long term operating costs should not be allowed to become unacceptable just to meet an initial cost." (CIE 1992) All outdoor lighting schemes should be designed to prevent unnecessary cost and minimize energy use, while providing lighting requirements, so these must be taken into consideration before design and implementation stage.
3. **Aesthetic requirements:** The aesthetics of the pole and fixture are visually important for urban identity during day and night. The lighting equipment should provide lighting that is appropriate in character, scale and size for each area and use. In the contrast with this point of view, the majority of current implementations include that selection of aesthetically pleasing fixtures only based on their appearance without any consideration to their photometric performance. On the contrary, in some arrangements, generally it is not possible to combine aesthetics and function with the poles and luminaries or limited area is designed properly as to aesthetical, technical and functional criteria but near area does not display equal quality and order.
4. **Light pollution:** Light pollution is becoming an increasing problem in modern urbanized society and must be dealt with. "One is the highly publicized problem of 'light pollution' and light trespass, which has been a major concern of astronomers, environmentalists, planners and lighting designers for several years." (Crawford 2001, p.17) For many years engineers have generally

overlooked it, this is because that the environmental problems such as air and water pollution have attracted much more attention from the public.

The majority of observers concentrated on main causes of 'light pollution' are poorly designed or out-of-date street and road fittings and the undoubtedly growth of security, sports, advertising and architectural lighting schemes; also unskilled technicians or operators have no considerations for the common lighting context or the surrounding environment as a whole; then the installations cause the light pollution. (CIE 1992)

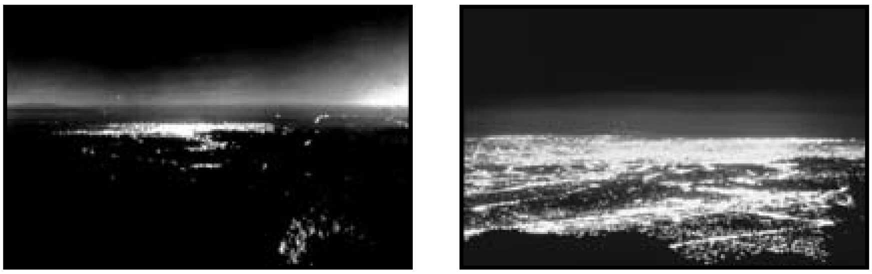

Figure 2.4 The level of light pollution in Los Angeles, California as shown in photos of the nighttime cityscape in 1908 (left) and 1988 (right), (Source: International Dark-Sky Association)

Light pollution is a generic term that encompasses many different aspects of improper lighting. There are three major components of light pollution including light trespass, glare, and urban sky glow.

- Light Trespass

Light trespass can be described as “the effects of light or illuminance that strays from its intended purpose. On a roadway lighting system, it is desirable to have all the light directed onto the roadway and not on the adjacent area. Poor quality lighting fixtures, which are generally of a non-cut off type, will allow some of the light to fall on areas away from the road such on lawns and houses”. (IDA, http://www.darksky.org/infoshts/is125.html)

Figure 2.5. Light trespass
(Source:http://www.volt.org/Geteducated/Skyglow.html)

A poor lighting design, which has employed the wrong luminaries' distribution, can also lead to unwanted light trespass. "The stray light that enters their property or windows upsets some people. Light trespass is easily quantifiable as a measure of illuminance and easily measured in the field by a standard light meter."(King 2000, p.27)

- Glare

Probably the most annoying and safety related aspect of light pollution is glare. In the other words, glare is excessive brightness that makes it difficult to see or causes discomfort. Light fixtures that do not control the light they emit cause glare. Instead of simply lighting the surface that needs to be lit, light spills out and shines into the viewer's eyes. The viewer may not be able to see other objects that are necessary to be seen. (www.umass.edu/masscptc/bylaws/Outlight_L.html) Glare is a factor in nighttime accidents in which a driver cannot adequately see other vehicles, pedestrians, cyclists or even poles or trees. Glare is a particular problem for older persons due to changes in the eye brought about by aging. (Bommel&Boer 1980)

Figure 2.6. Glare examples
(Source:www.town.acton.ma.us/olac/downloads/%20Development%20Committee.pdf)

Glare is described in two categories as follows:

- Disability Glare*:* Glare causes reduced driver's ability to distinguish objects clearly. “Disability glare is also known as "veiling luminance" and is caused by the effect of the luminance of a source illuminating the inside of the eye in which the light rays are scattered or reflected within the eye reducing the contrast of images on the retina.” (IESNA 2000, p.20-2)

- Discomfort Glare*:* It produces discomfort or annoyance without necessarily interfering with visual performance. According to Institution of Lighting Engineers (ILE), however, has reported that discomfort glare may cause fatigue that may result in driver error. This effect is very subjective and not easily quantifiable although several jurisdictions have applied some limits to the amount of discomfort glare permissible from a lighting system. IESNA 2000, p.20-2)

Besides, Bommel and Boer studies present the amount of disability glare can be calculated and measured readily by the equipment such as luminance meters. (Bommel and Boer 1980)

- Urban Sky Glow

IESNA identifies “urban sky glow is the result of stray light being scattered in the atmosphere brightening the natural sky background level. This effect is extremely detrimental to astronomers as well as annoying to many people in the general public. It is sometimes difficult to comprehend the effect of sky glow and the sensitivity of astronomical instruments”. (LPAG 1997)

Figure 2.7. Sky glow (Source: www. Light Pollution Gallery.htm)

"Street lighting has been blamed for up to 50% of the urban sky glow due to 95% of the light directed down toward the pavement being reflected upward at reflectance rates ranging from 6% for asphalt to 25% for concrete." (LPAG 1997)

5. **Safety & Security**: In recent decades, many studies have been done in order to find out the relationship between safety and security. Safety and security are vital elements in any urban development. "The creation of a sense of personal and community safety is a complex issue; the perception of personal safety or danger does not always relate directly to actual incidence of crime. We feel comfortable and confident using areas where there is good visibility and an effective lighting, where we feel we can be seen and heard by other people". (EP, 2003)

According to Clark, intense or continuous lighting does not necessarily assist personnel or property security. Urban crime rates have increased together with the growth in urban outdoor lighting. A casual link has not established through the studies. "Lighting at night allays the fear of crime, especially if the lights are close to being glare-free. However, there is virtually no reliable evidence that outdoor lighting prevents or deters crime. Instead, there is overwhelming evidence that light has a net facilitating effect on crime. Crime is a social problem, not a lighting problem." (Clark 2000, p.9)

The provisions of the British Crime and Disorder Act 1998 constitute a potential vehicle for lighting programmes operating within crime reduction schemes generally. Handbook of Loss Prevention and Crime Prevention, edited by Lawrence Fennelly, Girard contends, “good lighting is the single most cost effective deterrent to crime”. (Girard 1992, p.96)

Besides, Painter and Tilley have done sophisticated studies in line with street lighting improvements are associated with crime reductions in the day-time as well as during the hours of darkness. For example, the evaluation of Dudley and Stoke projects is published as Painter & Harrington, 1997.Victimization surveys (in which people are asked about crimes) have been employed, covering a 12-month before period and an equivalent 12-month follow-up period. Their researches hypothesis that improved street lighting leads to an increased number of people outside on the streets after dark has been also supported, as was it leads to a more favorable assessment of the quality of the area. They support the researches with qualitative and quantitative to conclude the studies. Also police records determine a negligible decrease in crime of only 2 per cent in the larger police area containing all the project areas. In Dudley and Stoke, crimes have decreased both in day-time and in night-time. Their observations demonstrate that the main conclusion is that improved street lighting led to substantial and cost-effective decreases in crime in the experimental area, and that there was a diffusion of the benefits to the adjacent area. (Painter& Tilley 1999)

In similar approach, Farrington& Welsh (2000), their investigation is based on a systematic review of the effects of improved street lighting on crime, the eight American studies that have been considered to meet their minimum methodological standards. In four evaluations the improved street lighting has been considered to be effective in reducing crime (Atlanta, Milwaukee, Fort Worth and – for violence – Kansas City). In the other four evaluations, the improved street lighting has been considered to be ineffective. The main conclusions are that lighting does not decrease crime but only allay the fear of crime, and that crime is a social problem rather than a lighting problem. (Portland, Harrisburg, New Orleans and Indianapolis). (Farrington& Welsh 2000)

Consequently, The U.S. Department of Justice reports that "there is no statically significant evidence that street lighting impacts the level of crime, but that there is a strong indication that increased lighting decreases the fear of crime. This leads to the conclusion that some lighting may make people more secure in the sense of feeling safer."(U.S Dept. of Justice)

2.3. Outdoor Lighting Design Principles

Many spatial elements make up streetscape. These elements, which are dominant in determining the cost and visual quality of a design, should be taken into consideration. Those who pay attention to urban design suggest two ways to determine the quality of design. The first one refers to the total quality of space resulting from the use of design elements that are lighting, paving etc. The second one includes the design detail that affects design of elements such as textures, materials, scales, colors and other factors of visual control. In this point of view Jon Lang identified that,

> "the urban design concern is with the way surfaces of the milieu can be used to create the affordances for specific standing patterns of behavior and aesthetic effects. Thus the concern is with the way they create a spatial character, allied with which are an enclosing character, furnishings and levels of illumination. The way of the surfaces and furnishings of a setting are lighted and the way the light or shade the spaces they make over the course of the day and night affect affordances for activities, comfort and aesthetic appreciation." (Lang 1994,p.192)

Outdoor lighting has for many years been considered only from a technical point of view. However, outdoor lighting installation should provide best-illuminated area and create promotional area, social interaction, identity, safety as well as technical considerations. For carrying out the better design of outdoor lighting, the general factors that affect and are affected by quality of lighting may be formed. These are:

- Design standards and quality
- Field conditions
- Human needs
- Cost

-Design standards: Generally, public institutions are responsible for establishing and controlling the design standards to be applied. The design standards include not only the technical knowledge but also the wholeness in the urban design. Design standards may be examined in three steps that are design concept, equipments characteristics and performance criteria in terms of the urban design quality. The quality may be expressed in aesthetical and functional quality besides economic quality. The technical details will be further discussed in the following sections in this chapter. From lamp luminaries to utility elements at underground should be determined and coordinated in the whole of the design. Lighting design performance is directly related with lighting concept and different public areas. In general, the common lighting design depends on the circulation network such as roadways and pedestrian paths.

According to Jakle, "the purpose of lighting is not only to illuminate but also to orient. It has to cue easy comprehension of the darkened environment." (Jackle 2001, 64) Recently, there is a widely concept about illumination for various activity areas. Another important principle for lighting, the selection of lighting equipment and the arrangement of lighting design have an important role in achieving better-illuminated areas. Beside that, design standards must be integrated with the other factors that are energy standards, cost, field condition, operating–maintenance controls and visual aesthetic.

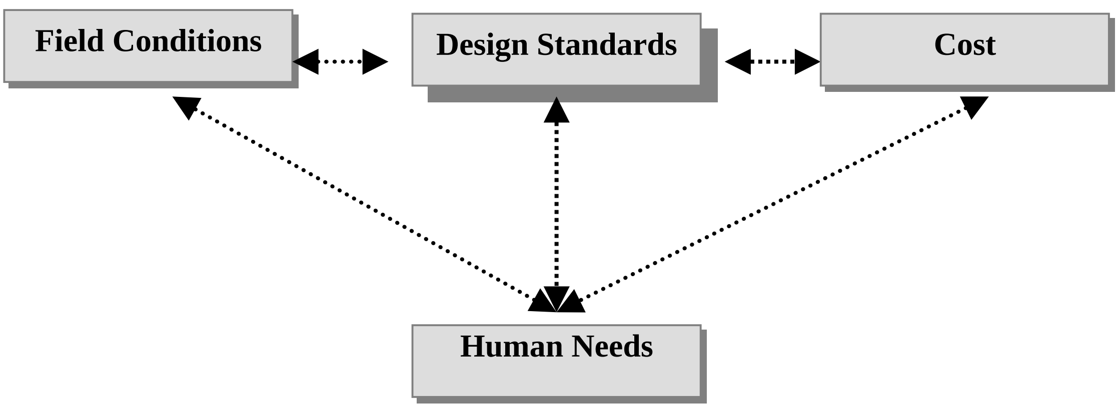

Figure 2.8. Interaction of outdoor lighting factors.

Also, general physical lighting parameters are defined as-mounting height, spacing, lamp type, and cut-off fixtures and etc. In addition the lighting parameters, requirements of structural composition include horizontal illuminance, uniformity and continuity, hierarchy and variety of different uses.

Jackle offers that "planners and lighting professionals should recognize that different urban areas and different kinds of city streets vary needs. They also should recognize that these needs varied between different sized cities." (Jakle 2001, p.65) Consequently, design standards are important to determine the project principles to establish high quality environment to night-time.

-Field conditions: The urban places have variety of activities such as roads, commercial, residential areas, walkway areas, public areas, and recreation areas. Lighting installations should be varied and designed in terms of the land-use specialization areas. Public realm is defined as squares, streets, parks etc and private spaces. London Borough of Croydon suggests that "the considerations in designing and choosing elements for the public realm include specifications and standards, performance requirements, minimization of clutter, safety and security, co-ordination of utility undertakers, durability, ease and quality of construction, cost and sustainability." (L.B.C. 2001, p.20) The public realm quality may be provided achieving the best streetscape improvements like lighting projects.

For lighting plans, human factor should not be forgotten in the field and illumination conditions. Safety and security for the environment and traffic and also technical standards are not the only factors for condition choices. The character of spaces must be taken into consideration together with the kind of nocturnal urban image.

***-Human needs*:** In lighting design, human needs include not only safety and security needs but also cognitive and aesthetic needs. According to Lang, "the urban design concern is with the layout of environments that provide safe and secure setting in which people can pursue their lives. Cognitive needs are basic to life and the aesthetic quality of the built and natural environment is an important mechanism in attaining a variety of ends. (Lang 1994, p.161)

The physical appearance, in both daytime and nighttime, often becomes a sensitive and sometimes emotional issue. Aesthetic considerations, which determine the "quality" of the outdoor lighting system, may include the scale of the equipment used and the order of the design. Physical aspects such as pole style, color, and material finishing, shape, height, and luminaries' type and size are often factors of sensitivity within the community. Beside that, for providing safety and security principles, firstly the appropriate illumination level and an effective and coordinated system should be provided.

-Costs: A lighting design that improves the safety, security, and appearance of an area may require much equipment and operate long hours. However, good lighting can produce benefits that outweigh the costs of a lighting installation. Recently the economic situation and cost related issues in realizing projects carries a heightened importance. Therefore, a major issue for architects, outdoor lighting designers and planners is the cost. Also, investigating the economic value of visual and aesthetic effects of various design goals may be achieved at a reasonable cost.

Initial cost, annual maintenance cost and energy cost should be considered in design proposals. "Initial cost includes the cost of the lamps, luminaries, ballasts, controls, poles, wiring and installation and maintenance costs are the annual labor and material cost of replacing lamps, ballasts and controls. Long life light sources, such as metal halide and high-pressure sodium lamps offer savings on lamp replacement costs, including labor. Energy cost is the cost of electricity used to operate the lighting systems." (Leslie & Rodgers 1996)

Cost considerations naturally come into play quite early in scheme development, and often have a strong influence on decision-making and design. There is a tendency to focus attention on the capital costs of equipment and installation, and to ignore the cost implications of operating the scheme. However, in the longer term, energy and maintenance costs may outweigh the scheme's capital costs in importance. Therefore it is strongly recommended that any decisions are based on a long term evaluation of the total capital and operating costs of the scheme over say a 30 year period. In addition, cost considerations always need to be weighed carefully against environmental issues. (Dept.E.T.R. 200, Leslie&Rodgers 1996)

Energy use and operating and maintenance controls are considered in the cost of outdoor lighting design.

-Energy Standards**:** Depending upon the selection of design standards and outdoor lighting equipment and system, the energy requirements differ widely from one project to another. For any particular system, there may be significant variations between initial energy requirements immediately after construction of a new roadway lighting system and long-term service life energy requirements. The energy requirements and the relative cost of energy may become an important factor in design standard decisions.

-Operating and maintenance controls: The type, design and location of lighting equipment can increase energy efficiency and help minimize the long-term operation, maintenance and repair costs associated with the lighting system. Many old street lighting systems, and occasionally new ones, are operated by a time clock. Automation is advantageous because all lights are turned on and off at the same time, giving the system a uniform appearance during that time of day. To assure longevity of a quality lighting system, maintenance practices must be specified to renew the system and to prevent a steady, long-term decline in the level of lighting service.

Consequently, lighting design must be interpreted as strategic approach that define the appropriate balance between allocated budgets and the proposed design of quality. Therefore, improved outdoor lighting will bring benefits in terms of encouraging more use of public transport, walking and cycling during the hours of darkness. Generally in lighting design projects, some factors related with urban design should take into consideration.

2.4. Outdoor Lighting Equipments

Contemporary examples of outdoor lighting find solutions together in urban equipment system very widely. To provide lighting that is appropriate for specific functions, equipment should be evaluated and selected based upon its characteristic advantages and disadvantages. The design, material and scale of lighting equipment are factors that should be considered in the development of a lighting system. Outdoor lighting should be integrated with the streetscape; also should not visually dominate and either the night-time or the day-time environment.

In outdoor lighting organization, lighting fixtures should be selected based on existing architectural standard and character. Coordinating fixtures in terms of types and materials should enhance visually the streetscape on the installation. Maintenance and repair of equipment should also be simplified because of the use of standardized parts. Outdoor lighting equipment generally consists the lamp (i.e., the light source), luminaire (i.e. the enclosure in which the lamp is located) and the pole, as presented in the following sections.

2.4.1. Selection of Light Sources (Lamps)

The most important element of the illumination system is the light source. The choice of light source is critical to the process of lighting design. It is the principal determinant of the visual quality, economy, efficiency, and energy conservation aspects of the illumination system. IESNA's definition's of the lamp as "An electric light source is a device, which transforms electrical energy, or power (in watts), into visible electromagnetic radiation, or light (lumens). The rate of converting electrical energy into visible light is call "luminous efficacy" and is measured in lumens per watt. (IESNA, http://www.darksky.org/ida/ida_2/info52.html)

There are six families of conventional lamps commonly used in outdoor lighting applications: incandescent, fluorescent, mercury vapor (MV), metal halide (MH), high-pressure sodium (HPS), and low-pressure sodium (LPS). Except for incandescent, they are all gas discharge sources, i.e. light is emitted when an electric current passes through the gas. Here are several criteria for selecting lamps for outdoor lighting use: life (i.e. how often the bulb must be changed), efficacy (lumens per watt), color rendering, color of light, lumen maintenance (how quickly the light output decays over time) and the level of optical controls it offers. (Bommel&Boer 1980, IDA 1999, IESNA 2000)

At this point in time, high pressure sodium (HPS), mercury vapor (MV) and metal halide (MH), that are high intensity discharge lamps, are the most commonly used lamps for outdoor lighting.

- Incandescent lamps provide a color rendition that is warmer and more pleasing than most electric-discharge lamps. However, they are also less energy efficient and shorter lived than electric-discharge lamps. For these reasons, the use of incandescent lamps should be limited to areas where their color characteristics are more essential, such as pedestrian pathways and courtyards. Low-voltage incandescent lamps (12 volts) provide a simple and safe alternative to high-voltage lamps (120 volts), but they are not appropriate where high illumination is required and should only be used for low-level lighting along such areas as walkways and stairs. (DTM 2000, Bommel& Boer 1980, Liebl 2003)

- Fluorescent lamps should be confined to subways and special applications where for practical reasons a long narrow light source is necessary. These tend to produce glare unless these are well baffled. These have a good color and superior life. Fluorescent is commonly used for indoor applications, but outdoor usage is increasing. The best fluorescent and compact fluorescent (CFL) sources have several advantages over metal halide: longer life, a much shorter warm-up time to full brightness, ability to switch them on and off several times each night without significantly shortening bulb life, and a white light that is spectrally much less polluting than that produced by metal halide. Disadvantages are: high brightness CFLs are not available, light output is diminished at low temperatures, and a lamp may not even start at very low temperatures. (IDA 1999, IDA 2000, AASTO 2001, Liebl 2003)
- Mercury vapor lamps produce a color in the green to blue-green spectrum that is not flattering to many natural colors. Color-corrected mercury vapor lamps improve the color rendition, but where purity of color is necessary, these are still lacking. Mercury vapor lamps have the longest life but the lowest energy efficiency among electric-discharge lamps. These are recommended for use as street lighting in residential areas where somewhat lower levels of lighting may be desirable and color rendition is a secondary concern. Because mercury vapor lamps emphasize the green of

foliage better than most other lamps, they are also a good choice for landscape accent lighting. (IDA 1999, IDA 2000, Liebl 2003, AASTO 2001)

- Metal halide lamps provide better color rendition than mercury vapor lamps, have a higher energy efficiency rating, and are relatively long-lived. This type of lamp is recommended for general area lighting in public areas such as commercial and community centers, pedestrian paths. (DTM 2001)

- High-pressure sodium lamps are very efficient and relatively long-lived. However, these provide poor color rendition, producing light with a golden cast that is not flattering to many natural colors. High-pressure sodium lamps are recommended for primary and secondary roadway lighting and parking lot lighting where efficiency, reliability, and maintenance are critical and color rendition is a secondary concern. (IDA 1999, Brandi&Geissmar 2001, IDA 2000)

- Low pressure sodium lamps give the most efficient energy consumption, but their operation is less stable if the voltage is low, especially using low loss gear. Although these have poor color rendering characteristics, these are still widely used in many industrialized countries, give excellent service and should not be overlooked. (Liebl 2003, p.8)

Consequently, selection lamps must be appropriate to function or activity. Briefly, Miller describes the criteria to meet objectives for lamps in the followings:

a. High efficacy and low energy consumption
b. Long life
c. Resistance to fluctuations in the electrical supply
d. Low capital cost
e. Good color rendition (Miller 2001)

Table 2.1. Lamp characteristics

Lamp	Wattage Range, ft	Efficacy Lumen/watt	Average life, Hours	Apparent Color
Incandescent	10-1000	210-2700	750-2000	Warm White
Fluorescent	15-215	1000-7500	10000-20000	Warm to cool w.
Mercury vapor	40-1000	1500-20000	12000-24000	Cool white
Metal halide	175-1500	1900-30000	10000-20000	Cool white
High-pressure Sodium	35-1000	3600-46000	18000-24000	Yellowish
Low pressure sodium	18-180	1800-33000	16000	Yellow-orange

(Source: Gionet 1988, Şerefhanoğlu&Bostancı 2001)

When the knowledge about lamps generalized, the following table 2.2 can be discussed; and thus table 2.2 displays lamps appropriate for purposes.

Table 2.2 Performance criteria of lamps

Lamp Type	Life	Efficacy	Color rendering	Cost	Lamp appearance and purpose
Incandescent	*Low*	*Low*	*Excellent*	*Low*	*Only use special purpose in pedestrian areas*
Fluorescent	*Medium*	*Medium*	*Good*	*Medium*	*Long tubular lamp compact versions available useful for special effects in exterior lighting*
Metal Halide	*Good*	*Good*	*Very Good*	*Medium to High*	*General area lighting in public areas*
Mercury vapor	*Excellent*	*Poor*	*Good*	*Medium*	*Residential (local area) street lighting and accent lighting for planting material*
High Pressure Sodium	*Excellent*	*Excellent*	*Poor*	*High*	*Primary and secondary roadway and parking lot lighting*
Low Pressure Sodium	*Good*	*Excellent*	*Very poor*	*High*	*Expressways, harbor , parking lots and security lighting*

(Source: Gionet 1988, Wood 1997, IDA 2000)

Lamps should be selected appropriate for the activities. Therefore, the table 2.3 shows which the lamps are appropriate for the activity areas.

Table 2.3. Light Sources For Outdoor Lighting Applications

	Incandescent	Fluorescent	Metal halide	Mercury vapor	High-pressure Sodium	Low-pressure Sodium
Indoor	✓	✓				
Roadways					✓	✓
Parking lots				✓	✓	✓
High mast					✓	
Walkways			✓		✓	✓
Recreation/sports			✓	✓		
Sign/billboard		✓	✓			
Historic area			✓		✓	✓
Building appearance			✓		✓	

2.4.2. Selection of Luminaries Types

"The distribution pattern of light on surface should vary depending on the specific application. This pattern is controlled by placing the lamp in a luminaire that distributes light in a given direction by use of an enclosure, reflector, refracting lens, are a combination of these." (LPAG 1997) When the lighting design will be formed, the most common luminaires will be compromised with the alternatives for optimizing energy efficiency and quality of illumination. Many lighting upgrade projects consist of replacing one or more of these components to improve fixture efficiency. Alternatively, users may consider replacing luminaire with one that is designed to efficiently provide the appropriate quantity and quality of illumination.

- Selected luminaires are important lighting tools in terms of cut-off terminology. Cut-off primarily is used for lighting medium to large areas, this luminary is very effective in minimizing direct glare. When deciding horizontal length between lighting fixtures and using with high efficiency, "Cut off Terminology" and Transverse Road Line (TRL), Longitudinal Road Line (LRL) is important terminology for better illumination. Cut off terminology is measured along TRL as given in Figure 2.9. (AASHTO 2001, Bommel&Boer 1980)

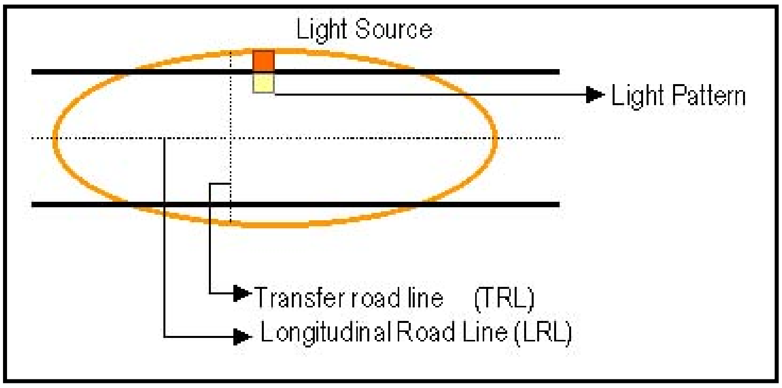

Figure 2.9. Street section. (Source: Gökçen, 1999)

The limiting TRL are:

- ✓ Short distribution – 3.75 MH
- ✓ Medium distribution – 6.0 MH
- ✓ Long distribution –8.0 MH (IESNA 2000, p.20-6)

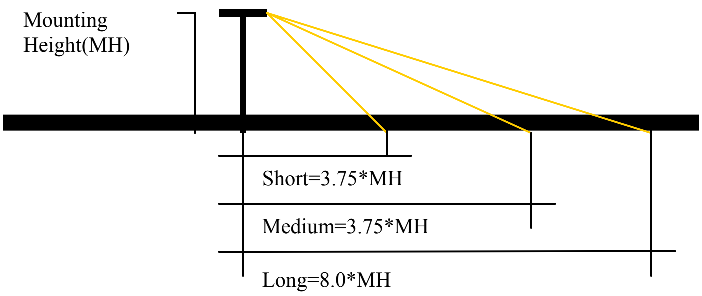

Figure 2.10. Types of distribution (Source: Robinette 1985, p.84)

- “Cut off means max of 10% light sources lumens falls outside the TRL area. Cut off is not ore than 2 ½ % of peak intensity radiating above 90 degrees and 10 % of peak intensity above 80 degrees”. (UDS Manual 2002, p.28)

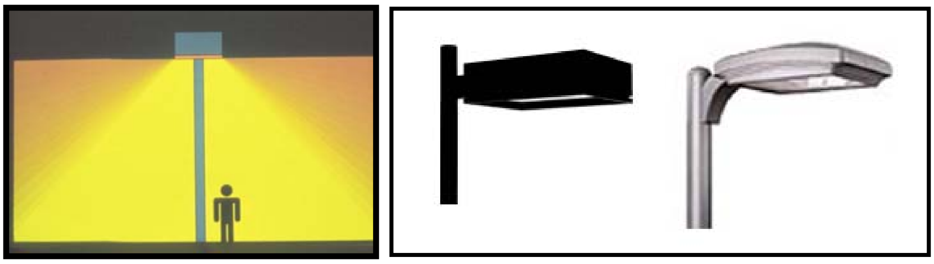

Figure 2.11. Cut-off luminaries (Source: IDA, http:// www.darksky.org)

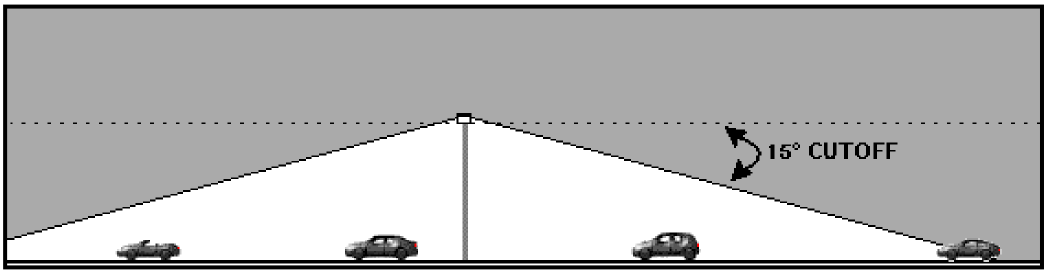

Figure 2.12. Cut-off luminaires (Source: IDA, http://www.darksky.org)

- Semi-cut off means max of 30% light sources lumens falls outside the TRL area. Semi-cut off is not more than 5 %of peak intensity radiating above 90 degrees and 20% of peak intensity above 80 degrees.
- Non-cut off means no control limitation. This is unrestricted high-angle illumination.

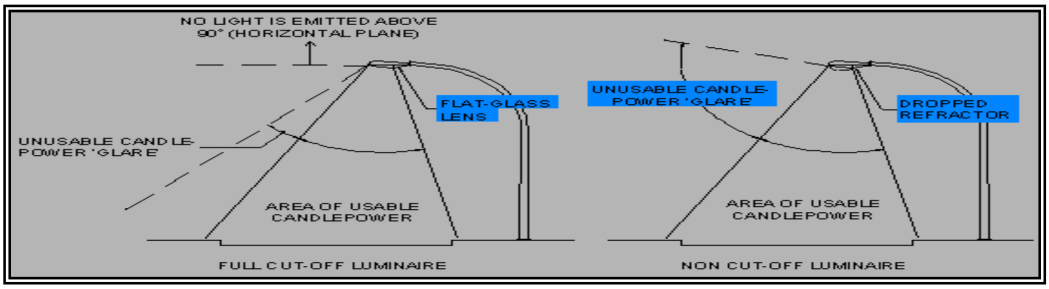

Figure 2.13. Full Cut-off and Non cut-off luminaries (Source: IDA 1997)

- The spacing of luminaires is often influenced by the location of utility of poles, block lengths, property lines, and the geometric configurations of the terrain features. (IESNA 2000, p.20-7) It is generally more economical to use larger lamps at reasonable spacing and mounting heights than to use small lamps at more frequent intervals with lower mounting heights. This is usually in the interest of good lighting provided the spacing and mounting height ratio is within the range of light distribution for which the luminaire is designed. (Bommel&Boer 1980)

- "Luminaire mounting heights are a function of maximum beam candlepower and type of cut-off. When practical, higher luminaire mountings than those shown in Figure are often preferable. Benefits of the higher mountings include less system glare, lower system installation cost with fewer luminaires per mile, lower maintenance cost per mile, less dirt accumulation, better distribution coverage on wide roadways and better system appearance." (IDA 52, 1999) "There may be locations, however, where there are conflicts, such as shielding structures over the roadway, tree conditions, or limited height conditions when lower mountings become necessary. In such instances, low brightness luminaires, smaller sized lamps or luminaires with lower angles of maximum candlepower may be used in order to avoid increasing the system brightness." (IESNA 2000, p.20-7)

- Luminaires for roadway lighting should normally be the "cobra head" style, "vertical" head style, or "high mast" style. Luminaires should only have photocells when the electrical service point (feed point) does not provide photoelectric control. (AASHTO 1984)

Consequently, luminaires must meet the following design criteria:

- ✓ Luminaires should be full cut-off and semi cut-off.
- ✓ Luminaires should be rain tight, dust-tight, and corrosion resistant.

2.4.3. Selection of Light Poles

Light poles are a significant visual element of the installation lighting system, especially in the day-time environment. "These are available in a variety shapes, materials and finishes and should be selected according to short and long term costs, functional considerations and aesthetic concerns". (Nyserda 2002, p.10) The designer must determine the pole height, type and material and finish, and method of mounting. Pole height affects the illumination intensity, uniformity of brightness, area covered, and relative glare of the unit. Luminaries can be mounted on existing utility poles to limit additional clutter. However wherever feasible, exterior lighting system should be provided with poles that yield the proper spacing and mounting height ratios for a given lighting problem. Pole height restrictions may cause more poles to maintain uniformity.

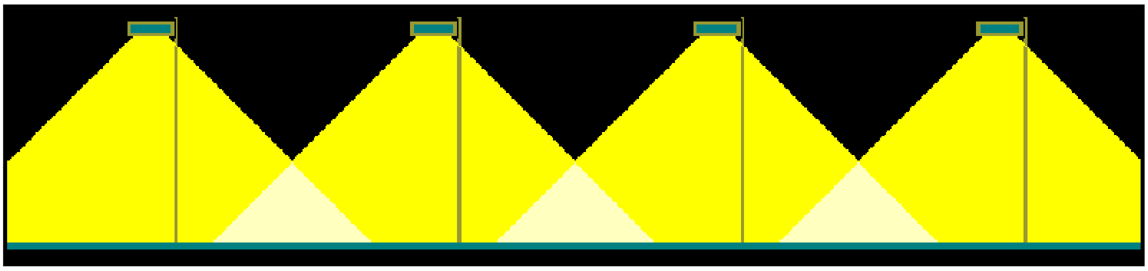

Figure 2.14. Uniformity (Source: Liebl 2003, p.13

"Some designer should attempt to reduce costs by decreasing the number of poles, using luminaries that have greater high angle luminance. These luminaries would achieve the illuminance and uniformity specifications sought fewer poles, but will do so at the cost of increased glare." (Liebl 2003, p.13) Higher mounted units provide greater coverage, more uniformity, and a reduction of glare, but a lower footcandle level.

- **Placement**: Pole placement is an engineering decision that should be based upon geometry, character of the roadway or area, physical features, environment, available maintenance, economics, aesthetics, and overall lighting objectives. "Physical pole conditions may require adjustment of the spacing determined from the base levels of illumination. Higher levels of illumination are justified when overhead structures, safety, and object clearances restrict the placement of poles. It is advisable to provide the higher illumination levels at diverging and merging areas". (IESNA, 2000, p. 20.7) Especially in residential areas, spacing, illuminance levels, distances between poles and decisions of location enhance the building blocks or the other land uses. The information of spacing will give the following the chapter.

-**Types of Poles**: Lighting poles generally include the followings:

a. Concrete poles are available in a variety of finishes and are compatible in a character with most settings from roadways to pedestrian areas. These are moderately expensive but require minimum maintenance. These are appropriate for most applications except high mast uses because it cannot exceed 15meter in height. Also, this height may increase, depending on setting, appear visually out of setting. (YTÜ Kentsel Tasarım Çalışma Grubu 1992)

b. Galvanized: The types of poles are appropriate in character for most uses and settings. These provide a thin profile. These are relatively expensive and require little maintenance. These are available in a variety of finishes, but when left natural should have a brushed finish to minimize reflection.

c. Painted Steel: This pole type provides a trim profile and relatively inexpensive, but it requires regularly maintenance. Generally, these should be avoided because of maintenance requirements. Their use generally should be limited.

d. Weathered and Decorative Wood: The types of poles are generally considered for special area applications where a high quality finish is desired for special area applications where a high quality finish is desired that blends with the aesthetics of a particular setting, especially in pedestrian or residential areas. These are relatively expensive and susceptible to defacement by vandals.

e. Weathered Steel. This type of pole is best used where high mast poles or minimum maintenance is required. These are inappropriate in pedestrian areas because of their scale and appearance and the weathered finish can stain. Initial costs are high but it’s practically for high mast applications is more than justified because it is relatively maintenance-free. (Miller 2001, Öztürk 1992)

Consequently, poles should be chosen based upon their functional and aesthetic appropriateness:

- ✓ Generally concrete and galvanize poles have advantageous in terms of maintenance; so, the common systems applies with these.
- ✓ Weathered steel pole should only be used for high mast type lighting in outdoor spaces where no pedestrian contact occurs.
- ✓ The pole system chosen should be used consistently thought the installation.
- ✓ Different pole types can be used for different systems for example, pedestrian and vehicular, but these should relate harmoniously especially in area where they may interface. Also, the poles used on an installation should be limited and the selection should display existing architectural standards.

2.4.4. Other Outdoor lighting Equipment

Lighting components can be grouped as the optical system, the electrical system, and the structural system. According to Miller, these are:

- ✓ The optical system is comprised of the light source (lamp), reflector, refractor, and housing, which comprise a luminaire.
- ✓ The electrical system is made up of the ballast, wiring, photocells, and other minor components.
- ✓ The structural system supports the luminaire and associated equipment and is comprised of the mounting brackets, pole, and foundation. (Miller 2001)

The optical system and structural systems are examined in the previous sections. Apart form these, the electrical system is related with main technical part for the lighting applications. It can be grouped as controllers and cables&wiring.

- **Controllers:** Outdoor area lights should be operated as needed from sunset to sunrise. Therefore, the objectives and equipments should be reduced or eliminated unnecessary usage as follows:

    - "Timers prevent outdoor lights from being left on during the day and provide other operating hour options if lighting is not needed throughout all hours of darkness.
    - Motion detectors turn on the light when an object moves within the range of the sensor. The time the light remains on can be adjusted, typically up to 30 minutes. These fixtures can be installed in conjunction with floodlights as an extra security measure. Detectors vary in price based on their sensitivity.
    - Photocell sensors can either turn lights on and off or be connected to a dimmer that gradually adjusts lighting levels. (http://www.pge.com/docs/pdfs/biz/rebates/express_efficiency/useful_info/outdoor_light.pdf)

- **Cables &wiring:** Undergrounding overhead utility wires are a key to achieving effective outdoor lighting. All cables can ensure protection from any corrosive elements in the soil it should be sheated in P.V.C. "All cables must be terminated in weather proof outlet boxes. All lighting fittings and switches must be weatherproof.

Where cables are permanently installed trenches should be dug and the cables buried at least 450 mm below ground level." (Bommel&Boer 1980, p.36)

2.5. Evaluation

This chapter attempts to define lighting equipments and system in both streetscape and infrastructure design. Also, it provides information in terms of illumination characteristics, lighting equipment for selection and application that need attention. An effective lighting design is needed to carry out a high quality lit environment. It requires including design concept and technical necessities.

In the lighting schemes, design concept should:

- provide visual impact of lighting equipment during day
- minimize the unwanted lighting problems, which are sky glow, light trespass.
- improved the quality design to realize human needs, field conditions etc.
- integrate the urban design and its components.

Technical requirements may be generalized as follows:

- Selection of proper lamps in respect to efficiency, luminous outputs, output maintenance, color size, environmental factors capital costs.
- Selection of proper luminaires that is related with cut-off terminology
- Selection of proper pole that is related with lighting distribution, uniformity and mounting height.
- And other technical considerations; for instance the overhead utilities should be located underground.

Consequently, this chapter provides simple and understandable language that may be used to define the lighting elements and design concepts.

CHAPTER 3

GENERAL OUTDOOR SPACE LIGHTING GUIDELINES

3.1. Urbanization and Outdoor Space lighting

"Awareness of the benefits of lighting the towns, cities and communities at night is growing."(Stranks&Berry 1995, p.1) Illumination concepts and illuminated areas have been improved with the urbanization. The major aim is to provide visual and spatial quality of urban realm with control amount of lighting. It is within context, "urban realm is concerned with the extension of leisure space that the 24-hour city has been conceived; for instance, European culture of using the public realm provide Millennium illuminations."(Cochrane 2003)

The qualities of illumination and improvements enhance visually structured urban space and provide both place promotion and sense of place after dark. The other common concept is economy for outdoor lighting. Carmona defines that a number of towns and cities achieved high quality illuminated area with economy, such as Croydon (London) and Edinburgh (Scotland) have adopted comprehensive lighting strategies. (Carmona et. al. 2003, p.180)

As the lighting benefits, some illumination problems cause adverse effects. The effects should be prevented and kept to minimum through the lighting regulations, field inspections at design and implementation stage. There is a great concern nowadays about controlling and limiting the environmental impact of outdoor lighting installations. More than 100 cities and countries have lighting laws, and interest in preserving dark skies is growing, according to the 11-year-old International Dark Skies Association. Also many cities have master lighting plans. The plans are based on providing safety and beautification of for goods and people.

Briefly, outdoor lighting in every scale can be arranged to provide comfortable, safe and effective vision at night. Outdoor lighting strategy needs to combine with related policies and strategies such as those related to pedestrian access, street tree planting, recreation planning and community safety. It is important that the system provide attractive, effective and efficient concept for each different urban areas that are streets, residential areas, commercial areas, public areas, main pedestrian routes, parking areas, recreation areas etc. according to diversity of land uses.

Consequently, this chapter describes desirable characteristics for each urban area. Therefore, firstly, the outdoor lighting requirements are defined from rural areas to city. Secondly, the chapter examines to land use provisions related to outdoor lighting by incorporating current concepts, improving lighting results throughout the city plans and improvements. It includes specific lighting levels, technical terms and standards as needed. This guideline is essential to create best-illuminated night-time environment.

3.1.1. Rural Areas

Lighting in rural areas is currently controlled primarily through the planning system. While noise pollution, excessive lighting is not recognized. In general, road lighting have been adopted the following broad standard provision for roads:

- No lighting on new rural roads,
- Lighting on all roundabouts and some T-junctions.

Lighting on rural roads should be designed, so that pedestrians can orientate themselves and detect vehicular and other hazards. Nevertheless, rural areas both homes and on farms and commercial properties increasingly need security lighting because of increasing of theft and vandalism. If such lighting is over-bright and properly directed, it can be highly intrusive. The problematic solutions should be prevented with designs and the local control systems." (Stranks&Berry 1995)

On the other hand, lighting that is sky glow from major towns and cities brightens and colors the background the sky is a major problems for the rural life. The problems are classified as wasted energy contributes to global warming and other ecological problems. (IDA 2000 ,http://www.darksky.org)

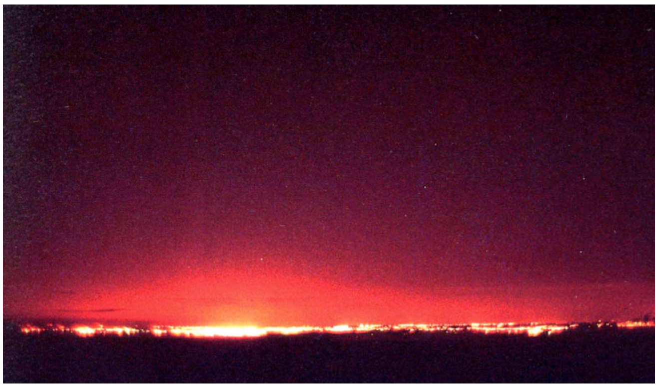

Figure 3.1 Sky glow from Poole ferry terminal
(Source: CIDS image library taken by B. Mizon,)

It is therefore important to maintain a clear, logistic approach and to avoid the cumulative intrusive impact of light designed for different purposes. So, in rural areas, outdoor lighting is concern for all those interested in preserving the natural night-time environment and minimizing any adverse effects on plants and wildlife.

3.1.2. Urban Fringe

Urban fringe includes all small urban areas (with less than 10,000 population). Road lighting is the dominant source of night-time lighting in rural areas. "Ribbons of road lights cut through suburbs between urban centers, and light from out-of-town shopping centers, industrial and commercial estates and leisure facilities light up the surrounding countryside". (Stranks&Berry 1995, p.10)

Green: Leisure facility, controlled lighting
Blue: Industrial Estate, controlled lighting
Red: Village center, minimal street lighting
Orange: Road network, mainly unlit
Black: Unlit countryside

Figure 3.2. The schematic of an urban fringe area (Source: Stranks&Berry 1995, p.10)

On unlit cross-country traffic routes, drivers are used headlights for forward visibility. Sudden or frequent variations in lighting levels as drivers' approach the urban fringes should be keep to a minimum.

Stranks&Berry demonstrates the balance of lighting in urban fringe areas with the visual scheme. According to they, "the balance of lighting should be in favor of control with no light where possible and careful optical control where lighting does intrude. Unfortunately, low-pressure sodium lamps, which have very poor color rendition, are particularly common on urban fringe roads and in village streets." (Stranks&Berry 1995, p.10)

The over bright illumination in urban fringes can be controlled to reduce the negative effects and distribution of the luminaires to that required for safety and security. For example, a growing many suburbs, in recent years, has expanded its community facilities to accommodate the needs of population and widening industrial base. For the urban fringes, the controlled lighting schemes should be designed and installed for especially new projects.

3.1.3. Towns

Outdoor lighting can become a fundamental tool for understanding of towns as well as cities, allowing the basic lines of their structure and distinctive characteristics. In fact, a town lit up at night creates a very precise image of the area in the memories. The memory of the place is vital to the town's image which lasts much longer than any darker image. Today, night lighting in towns means that a part of certain image to improve logic of conservation with light.

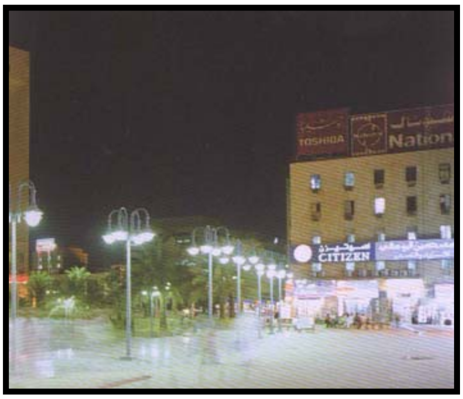

Figure 3.3. Town center in Kuwait city (Source: Siteco 2003, p.37)

The town center cores are more special areas for all towns. The fact that the core city has more importance, the all arrangements are implemented on the town centers like lighting arrangements. Therefore, the town centre core should receive most attention.

Green: Urban Fringe
Blue: Industrial Estates
Yellow: Civic center, high lit buildings
Red: Shopping center, well lit
Orange: Road network, with streetlight.
Black: Residential, minimal necessary lighting

Figure 3.4. The schematic of a town (Source: Stranks&Berry 1995, p.14)

Lighting approach for the town is seen more complex than rural areas and urban fringe areas as shown above Figure 3.4. (Stranks&Berry 1995, p.14) In town, outdoor lighting is taken into account for the demands of different zones. The residential area surrounding the center requires lighting for safety but there may be limited scope for highlighting, other than religious buildings, public houses and parks and gardens. Industrial and commercial areas are frequently dominant centers of lighting. Access, safe working and security are seen as the prime requirement by occupants.

Consequently, the use of lighting should be friendly to the needs of the town and its residents. The environmental quality of the town should be conserved and enhanced by encouraging the appropriate use of integrated lighting wherever possible.

3.1.4. Cities

Illumination of cities is getting more important beautify the scene. In general, city lighting requires careful planning. Also, it aims to emphasize historical and artistic values of a city through outdoor lighting sources. Besides that, according to Jonathan Speirs approach focuses on “taking a holistic approach to improving the overall experience of the city during the hours of darkness. Light structures the city after dark providing legibility ……… also bringing entertainment, excitement and civic pride". (Cochrane 2003)

"The lighting of values, which is important for city appearance and aesthetic within the except technical lighting that is necessary for safety and security, takes place in the city beautification. According to Prof. Hao Luoxi, many cities face equally challenging task to generate lighting planning that would blend harmoniously with urban form and nightscapes."(Luoxi 2000)

In similar approach, Avila defines "city that takes part in the mechanism and its image is built between the tension of what it is physically and the compulsion to position it in the regional and global context by means of advertising visual strategies. The city, like commercial products, is being advertised by means of trademark images that make up the frame the strategies of distinctness. And the city is being made visible so that it regains its meaning by insisting on the competitive appearance of urban scenarios." (Avila 2001, p.195)

Therefore, city residents may have to cope with many competing pressures. "Lighting may be one way in which this competition between differing views on what a city represents and its purpose is demonstrated. There can be competition between the needs of commerce and the needs of civic pride. While there is unlikely to be a compromise, which will satisfy all desires, there is the ability to create an overall impact and effect under a cohesive city-wide lighting concept." (Stranks&Berry 1995, p.16) A lot of many developed lighting strategies are such as Lyon, Melbourne, San Francisco, Cambridge, Bankstown and Cambridge etc.

Figure3.5. The nightscape of Melbourne (Source: McDonald, 2003)

In general, cities have identities because of their qualities. When the daylight disappears, the night-time lighting becomes importance. As a result the lighting takes the primary role to strengthen the quality of nightscape for cities.

Also lighting strategies are important; for instance, “in 1994 by the Royal Fine Art to all local authorities to adopt lighting strategies, Glasgow City Council's ‘Glasgow: City of Light’ is one example of a number of schemes which aim to provide new levels of composition and unity in outdoor lighting. With its emphasis on creating safer streets and on bringing new life to the city’s wealth of grand civic spaces, the strategy applies a Lynch-style structure of lit components to the city’s threshold spaces, gateways, nodes and historic crosses and landmarks.” (Speirs et. al. 2002)

Recently, most cities have completed the strategic design based on outdoor lighting. One of the impressive European outdoor lighting strategies to date were developed by the city of Lyon in France, where over the last five years there has been explosion of creative lighting applications, encouraged and coordinated by the local authority. “Lyon's Public Lighting Plan, launched in 1989, is the result of a concerted effort on the political, technical and artistic levels. It is both a program for spotlighting the city's most prestigious sites, and also a forum for debating the evolution of functional public lighting. The inventiveness, quality and scope of Lyon's program have set the standard in this field. With over 250 illuminated sites, the Lighting Plan gives a new nocturnal appearance, creating a more modern and friendly image, while emphasizing local identity”.(http://www.mairie-lyon.fr/decouverte/plan_lumiere/en_plan_lumiere_1.html) Consequently, outdoor lighting has entered a new era in Lyon as a component of urban planning policy

Figure 3.6. View of the Place of Terraux in Lyon.
(Source: http://www.area.progetto-ed.it/ar36/e/e1.htm)

The difference between a town and a city is often only one of scale. The city densely structured urban spaces. It is an area where lighting is so dominant at night that normally any appreciation of the natural dark environment is overwhelmed. "For cities, the lighting system is emphasized in an integrated approach. Generally the cities, such as İstanbul, "are the center of a conurbation of towns. Those cannot be seen in its entirety from a distance. The visitors may have difficulty in distinguishing when he has actually reached the city." (Stranks&Berry 1995, p.16)

Green: Industrial estates
Dark Blue: Residential areas, careful control
Blue: Leisure areas, extensive night-time use
Yellow: Civic and business areas, building highlighting
Red: Retail center, varied lighting
Yellow Arrow: Approach routes, selective building lighting
Red Arrow: Skyline view of center, showing highlights
Black: City fringes, normal lighting
Orange: Road network, full street lighting

Figure 3.7. The schematic of a city (Source: Stranks&Berry 1995, p.16)

The schematic of a city demonstrates "the increase in scale from a town and the need to give greater consideration to views of the city center from its fringes and to create a feeling of anticipation when approaching the center by increased lighting along its approaches." (Stranks&Berry 1995, p.16)

Figure 3.8. Lighting zones by category of street in a hypothetical city.
(Source: Harrison et.al. 1930, p.22)

The diagram clearly illustrates how urban designers and lighting engineers categorized city streets hierarchically, with busiest thoroughfares and downtown areas are lit at highest intensities. Today, urban areas are carefully defined, with lighting recommendations for each category based on specific of illumination, as well as luminaire mounting height, spacing and positioning. (Harrison et. al. 1930)

Lighting strategy for the cities must be the primary objective. The strategy concentrated on improving the quality, consistency and efficiency of night lighting in streets and other public spaces. While the lighting strategy and plans are preparing, the criteria are taken into account:

- The lighting approaches should be made the city visible when moving from the distant view into the city. The highlighting of structures and features should emphasize the routes into the center and should mark the transition from suburb to central area.

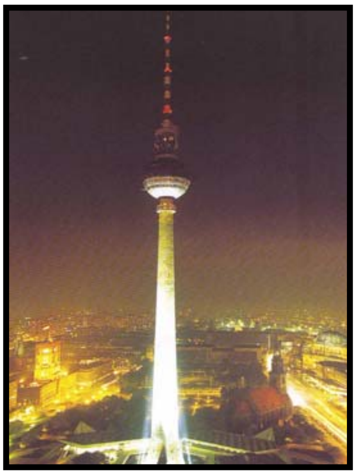

Figure 3.9. The television power in Berlin. (Source: Siteco 2003, p.16)

- "The scale of the architecture and spaces should be complimented by appropriate lighting The mounting heights and illuminances of the lighting should bring out the relative importance of street elevations and open spaces, creating a pattern of local interest and detail." (Stranks&Berry 1995, p.16) In fact, many of Japanese cities have good examples of city lighting harmonized in the structure of the urban equipment.

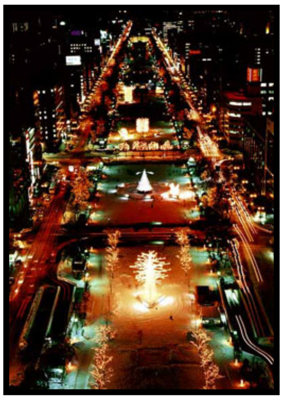

Figure 3.10. View of the Sapporo in Japan
(Source: http://www.juniorchamber.org/english/news/101300_news_en.htm)

- Different illuminated areas should be understand through the movement in the city by vehicular or on foot.

Consequently, in fact, lighting master plan for the urban environment functionally and aesthetically integrates within the built environment. Also, the lighting plan must be integrated with the other existed development plans and decisions (urban areas, traffic, greenery, noise etc.) prepared by local authority. And it must constitute a reference for the local authorities.

3.2. Outdoor Lighting Issues in Practice

Outdoor lighting is a general term that can include residential, commercial, industrial, institutional, transportation, and other uses. Planners and lighting professionals recognize that different urban areas and different kinds of city streets vary lighting needs. If the outdoor lighting is adopted in urban life and outdoor spaces, the hierarchy of light levels is based on land uses and urban design policies.

Lighting guides and standards have been improved especially by the institutions which are Illuminating Engineering Society of North America (IESNA or IES), the professional society of lighting engineers, designers and manufacturers whose purpose is to establish scientific lighting recommendations; International Dark-Sky Association (IDA), a non-profit, membership based organization whose goal is to stop the adverse environmental impact of light pollution through education about the value and effectiveness of quality night-time lighting and about the solutions to the problems. Through these studies, many ordinances and guidelines have been developed for many towns and cities. Specific luminance levels have been recommended which relate to a classification of environmental zones and environmental zones. According to different points of views, there are different classifications in terms of outdoor lighting performance criteria and design guides. Lighting Zones have been established to allow lighting with different intensity and character in different parts of the city.

IESNA defines four environmental zones with differing requirements for the control of obtrusive lighting are defined as follows:

- E1: Intrinsically dark landscapes: state and national parks, conservations areas, rural areas, residential areas with minimal or no outdoor lighting, and areas adjacent to optical astronomical observatories.
- E2: Areas of low ambient light levels: suburban and rural residential areas.
- E3: Areas of medium ambient light levels: urban residential areas
- E4: Areas with high ambient brightness; normally urban areas of mixed residential and commercial use; a high level of nighttime activity. (CIE 1992)

The classification does not clearly present differences of lighting principles according to urban areas. In this section, the illumination standards and principles are explained in detail. The purpose of this section is to show how the lighting design for an area can be approached in a coordinated way, integrating the recommendations from existing guides and codes of practices. In addition, the guidelines for this study are based on the land uses decisions and urban design policies. Specific lighting standards (for roads, area lighting, sports facilities etc) are covered in following headings that are described the standards, and specific procedures for designing the principal types of lighting found in urban areas.

3.2.1. Residential Lighting

Residential lighting affects everyone. An effective residential lighting should provide sufficient illumination needed to perform household tasks, be comfortable, and be controlled easily. But, the effectiveness and enforcement of residential lighting is always problematic.

The following lighting standards should be applicable to rural, single and multi-family residential development:

- Outdoor lighting should be 3.5 meter or less in height. All light sources that are not fully shielded should use other than a clear lens material, as the primary lens material, to enclose the light bulb to minimize glare from a point source.
- Security lights should be restricted as follows:
    - The point light source should not be visible from adjoining lots or streets.
    - Floodlights must be controlled by a switch or preferably a motion sensor activated only by motion within owners property.
- Timer controlled flood lights should be prohibited.
- Photocell lights should be allowed under the following circumstances:
    - At primary points of entrance (e.g. front entries) or in critical common areas for commercial and multi-family properties;
    - Where the light sources are fully-shielded by opaque material (i.e. the fixture illuminates the area but is not itself visibly bright); and

- The light source or fluorescent (or compact fluorescent) to eliminate excess electricity consumption.

- Lights must be fully shielded, down directed and screened from adjacent properties in a manner that limits light trespass to .1 of a foot candle as measured at the property line.
- No light fixture should be greater than 3.5 meter in height. Exceptions are:

  - Tree mounted fully shielded, downward directed lights using a light of 25 watts or less,
  - Building mounted flood lights fully shielded, downward directed lights using a light of 50 watts or less.
  - Light trespass at property lines should not exceed 0 .1 of a foot-candle as measured at the brightest point.(IESNA 2000, CIE 1992, DPM 2001, P&Z DG, LPAG 1997)

The following lighting guidelines provide direction in utilizing techniques to supply safety and security for residents, as well as create thematic design for, and enhance aesthetic of single, rural and multi-family residential development.

- <u>Rural neighborhoods:</u>

Small housing estates and linear developments are common in rural settlements. Many are lit, even though the rest of the village may be relatively dark.

-Design: Outdoor lighting requirements in predominantly rural areas differ greatly from the lighting needs of the urbanized community. "Specialized purposes of functions of lighting in rural areas, and desire to minimize outdoor lighting so that the night-time skies can be enjoyed, negates the need for pole-mounted lighting fixtures to illuminate rural roads; except at the primary entrance to a rural road serving the area." (P&Z DG 2002, p.138)

-Height*:* In those rural areas where pole-mounted fixtures are required, the exterior pole-mounted light fixture should not exceed five (5) meter in height, measured from the finished grade to the top of light fixture.

- Single Family Neighborhoods:

-Design: Outdoor lighting in single-family planned residential neighborhoods should be architecturally integrated with the thematic design aspects of the development as well as the building styles, materials and colors used in the development. "Street lighting fixtures and levels of lighting in these neighborhoods should reflect the vehicular function and character of the street; with shorter light fixtures and lower lighting levels on local streets, and taller light fixtures and higher light levels for more heavily traveled arterial streets". (P&Z DG 2002, p.138)

"Street lighting fixtures for local neighborhood streets having curb-separated sidewalks should always be placed within the landscaped area between the back of curb and sidewalk. Lighting of individual residential lots should be located and shielded in a manner so as not to increase the overall ambient light level of adjoining residential lots." (Corten 2001, p.203)

-Height: Street lighting fixtures in single-family neighborhoods generally are proposed no taller than five (5) meter measured from finished grade to the top of the fixture. These should be spaced in an alternating manner on either side of the street to provide an adequate distribution of lighting along the street. Pole lighting for safety and security of neighborhood open space, trails, bicycle paths and pedestrian ways should not exceed 3.5 meter in height; and should be supplemented with lower light levels using "bollard" or "foot" type lighting systems. (PEC 1988, P&Z DG 2002)

-Luminaries: Lamps should be metal halide in a luminaire that is classified by IESNA as a full-cut-off. Maximum wattage in general shall not exceed 100 Watts. (IESNA 2000)

-Illumination levels: Illumination levels should be minimum 10 lux on the ground. (Gionet 1988)

- Multi-Family Residential Developments:

-Design: Exterior lighting of multi-family and other higher density residential development should always reflect and enhance the architectural style and character of the development. Lighting at entry monuments and gates should be an integral part of the total landscape and building architecture of the development. (P&Z DG 2002,p.138)

-Height: Pole-mounted lighting fixtures along roadways within multi-family developments should not exceed five (5) meter in height, measured from finished grade to the top of lighting fixture. Open space and pedestrian ways in a multifamily complex should be lighted by a combination of pole-mounted fixtures not to exceed 3.5 meter in height, bollard-type lighting fixtures not to exceed 1.2 meter in height. The use of building or roof- mounted lighting to illuminate areas within a multi-family residential development should be prohibited. (Mcdonald 2003, YTÜ Kentsel Tasarım Çalışma Grubu 1992)

-Luminaries: Lamps should be metal halide housed in a luminaire as a full-cut-off.

-Illumination levels: "Lighting levels within multi-family residential developments should be sufficiently balanced to ensure the safe and secure movement of vehicles and pedestrians. Illumination levels should be minimum 10 lux." P&Z DG 2002, p.138) Illumination levels of the pedestrian routes will be declared the following sections as 3.2.3.1

3.2.1.1. Security Lighting

Security lighting is outdoor lighting installed only to enhance the security of people and property. The relation between lighting to security is uncertain and complex. In the context of lighting design the word "security" is often used in the sense that the lighting "provides a feeling of comfort or freedom from worry for the people using the area"(IESNA, 2000)

Security lighting should especially be designed to control glare and direct view of illumination sources, and to keep within limit of illumination on located. Lighting fixtures that are aimed at a building are much more effective for security than fixtures that are mounted on the building and that can blind observers of the property (Police, neighbors or others)

Security lighting should be High-Pressure Sodium (HPS). For small-scale security lighting, a 150W halogen lamp is more than adequate. Higher wattage lamps create too much light, more glare and darker shadows. Motion detector-activated lighting uses less energy and provides better security than constant light. Encourage low-level lighting which works better with closed circuit television cameras (CCTV). (IESNA 2000)

3.2.2. Non-Residential Lighting

The design and installation of proposed lighting in new and existing commercial, office, industrial and business park development should involve to the following guidelines. These ensure compatibility with the community's character and identity, and creation of a festive atmosphere for those pedestrian-oriented commercial areas of the city designed to encourage night-time use.

-**Design**: All non-residential developments should provide an exterior lighting plan during the city's technical review of the project. "The lighting plan should clearly represent the type, size, height, location, aiming point and design characteristics for each light standard proposed for buildings, parking areas and pedestrian ways". (P&Z DG 2002, p.139)

The design of lighting fixtures and their structural support should be of a scale and architectural design that is compatible with on-site buildings. Large non-residential developments having multiple, separate building sites should have a consistent, thematic, lighting fixture and structural support design and scale throughout the development.

The following lighting standards should be applicable to all non-residential properties including mixed uses:

- Outdoor lighting used to illuminate parking spaces, driveways, maneuvering areas, or buildings should conform to the definition for "fully shielded light fixtures" and be designed, arranged and screened so that the point light source should not be visible from adjoining lots or streets. The light level should not exceed 10 foot-candles as measured 90 centimeter above finished grade. Exemptions may be requested for areas with high commercial, pedestrian, or vehicular activity up to a maximum of 20 foot-candles.
- Outdoor lighting should be 3.5 meter or less in height unless it meets one or more of the following criteria:

  - Fully shielded with a non-adjustable mounting; or
  - Lighting for parking and vehicle circulation areas in which case heights up to a maximum of 6 meter may be allowed; or
  - Building mounted lighting directed back at a sign or building façade; or

- High Intensity Discharge (HID) light sources are allowed with a maximum wattage of 175 high-pressure sodium (HPS) and 175-watt metal halide.
- Spacing for security and parking lot light fixtures that are pole mounted should be no less than 23 meter apart. Decorative fixtures (which are also fully shielded) are allowed to maintain a 15 meter fixture spacing. Wall mounted fixture spacing for security lighting should be no less than 15 meter. Decorative fixtures directed back toward a building face should be exempt from this spacing requirement when shielded and should not exceed 50 watts. Decorative fixtures that are not shielded should maintain a minimum spacing of 8 meter and should not exceed 50 watts. Where security lighting is a combination of pole and wall mounted fixtures, minimum spacing should be 23 and a maximum of 46 meter.
- Pole mounted fixtures should be limited to two light sources per pole.
- Mixed use areas that include residential occupancies should comply with the residential standards on those floors or areas that are more than 50% residential based on square footage of uses. (IESNA 2001, Wood 1997, CIE 1992, IDA 1999)

All outdoor lighting installations should be served by underground electrical service, and include timers, dimmers and sensors in order to reduce overall energy consumption and eliminate unnecessary lighting.

3.2.2.1. Sign Lighting (advertisements)

Signs may be illuminated only during hours that the business being advertised is open for business. “Illuminated signs often require the express consent of the local planning authority and, when they do, assessment will be based on upon ‘size’, ‘amenity’ and ‘public safety’. The form of illumination, internal and external, can also effect the decision. Advertisements are controlled by regulations.” (Stranks&Berry 1995, p.28)

- Externally illuminated signs:

  - The average level of illumination on the vertical surface of the sign should not exceed 3 footcandles.
  - Light fixtures illuminating signs should be carefully located, aimed and shielded so that light is directed only onto the sign façade. Signs which are illuminated in the colors red, green or amber, either by colored bulbs or tubing, or which produce high reflection through the use of special preparations such as fluorescent paint or glass, may not be located within a radius of 600 meter of a highway traffic light or similar safety device.
  - To the extent practicable, fixtures used to illuminate signs shall be top mounted and directed downwards. (IESNA 2000, LPAG 1997)

- Internally illuminated signs are by their nature unshielded light sources in communities with good light shielding practice.

  - Internally illuminated signs consist of light colored lettering or symbols on a dark background.
  - The lettering or symbols should constitute no more than forty (40) percent of the surface area of the sign. (IESNA 2000)

On the other hand, neon lighting should be permitted for advertisement lighting.

3.2.2.2. Service Station Lighting (Gas Station, Convenience Stores)

Service station lighting includes both canopy lighting and lighting around service pump islands. Lighting levels on gasoline station/ convenience store aprons and under canopies should be adequate to facilitate the activities taking place in such locations without creating glare onto adjacent properties or roadways. Lighting of such areas should not be used to attract attention to the business. (P&Z DG 2002, LPAG 1997)

- "Areas on the apron away from the gasoline pump islands used for parking or vehicle storage should be illuminated in accordance with the requirements for parking areas set froth elsewhere. These are should be illuminated so the average horizontal illuminance at ground level is 30Fc or less, with a uniformity ratio 1.25". (LPAG 1997)
- The off-street parking and fueling area may be illuminated. The cut-off light should be at an angle of less than 90 degrees. Maximum foot-candle levels should be four (4.0) foot-candles as measured at the property line and one (1) foot-candles as measured at the property line abutting a residential district. (IESNA, 2000)
- The position signs should be designed so that they are visible only from the carriageway and not form the surrounding landscape.

3.2.3. Outdoor Recreation and Sports Lighting

Cities have public open spaces that promotes for evening use. These areas include parks, ball fields, paths, fair grounds and other types of public open space. In the design each of these facilities are to be included in urban and engineering design process like outdoor lighting design.

Outdoor lighting of parks, open space and recreation areas must provide for both safety and security of the public, as well as a variety of ambient light levels conducive to enjoyment facilities during the nighttime hours. "Lighting guidelines for outdoor lighting of parks, active open space areas and sports and recreation fields strive to meet the balance between public safety and enjoyment of outdoor passive and active recreation areas during in nighttime hours." (P&Z DG 2002, p.141)

3.2.3.1. Pedestrian Spaces Lighting

The primary purpose of pedestrian lighting is to extend the use of the nighttime environment and provides for the safety and security of pedestrians. Pedestrian lighting can also help to reinforce the hierarchy of the installation walkway network. Lighting standards should be adequately achieved, but not excessively. The illumination areas compromise not only urban space but also the elements within those spaces such as stairs, walls, benches, curbs and landscaping.

"Lighting of sidewalks and pedestrian crossings should be the primary focus of new street lighting projects. In places where pedestrian activity is important and encouraged, street lighting should properly illuminate sidewalks, street-crossing areas, and provide uniform lighting on the city roads". (Salt Lake 2003, p.5)

-Design*:* Street lighting in pedestrian areas should provide a uniform lighting along the pedestrian network. "Lighting levels should allow pedestrians to clearly distinguish the edges of the walkway, changes in direction, intersecting walkways and any potential obstacles or hazards. Street crossings, changes in grade and other potentially hazardous locations should be illuminated at a higher level than other sections of the walkway." (Salt Lake 2003, p.4) Light fixtures should be located so that they do not block up pedestrian traffic. Light fixtures should be located to minimize shadows and illuminate areas adjacent to the walkway to provide a sense of security

"The light poles and fixtures should be selected to complement the roadway and parking lot lighting, as well as the other elements of the streetscape. Bus shelters, telephone booths, kiosks and other site furnishings should be adequately lighted for night-time use for both security and functionality. Where possible the light source should be incorporated into the structure of the furnishings." (P&Z DG 2002, p.142)

“The lighting criteria of primary importance in the fulfillment of these pedestrians’ demands are lighting level (illuminance), uniformity (specially illuminance uniformity) and glare restriction.” (Bommel 1980, p.260)

In cities, “cobra head” street lighting generally provides the majority of street lighting. The lighting pattern may be effective for the roadway, but is not effective for pedestrians due to the vertical lighting as shown below. The “cobra head” streetlight creates a spot light effect along the road as shown in figure 3.11.

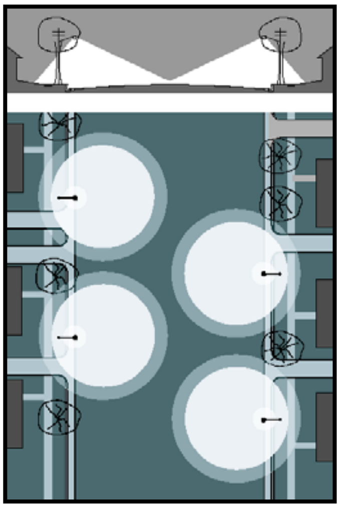

Figure 3.11. Cobra Head Street Lighting (Source: Salt Lake, 2003, p. 6)

Figure 3.12.b shows how pedestrian style streetlights are located the two lines and provides continues type of lighting needed to invite pedestrian activities during evening hours. The pedestrian style lights with a resident side light shield helps prevent light trespass that would prefer for those that would prefer this option.

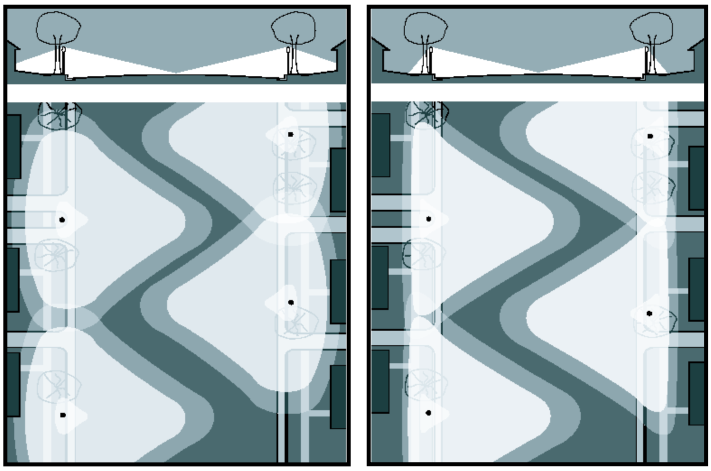

Figure 3.12. (a): Pedestrian Style Lighting (b): Pedestrian Style Lighting with Resident Side Light Shield (Source: Salt Lake Master Plan, p:8)

-Height: Mounting heights for pedestrian lighting should be appropriate for the project and the setting.

- Low-level lighting refers to fixtures in which lamp is mounted below eye level. (Lighting, p.97) It is generally used along the edges of walkways, ramps and stairs to illuminate the pedestrian pathway. Bollard fixtures should be 0.9-1.2 meter in height. Bollard lighting should emphasize and highlight unique features of a landscape treatment and directional movement along pathways. (P&Z DG 2002, p.142)
-

Figure 3.13. Bollard fixtures
(Source: http://www.afcee.brooks.af.mil/dc/dcd/land/ldg/s16 ExteriorLighting/c03Guidelines

In particular, utility in lighting stairs, ramps or walkways adjacent to walls are flush or semi-flush wall-mounted fixtures that direct light downward to the pavement

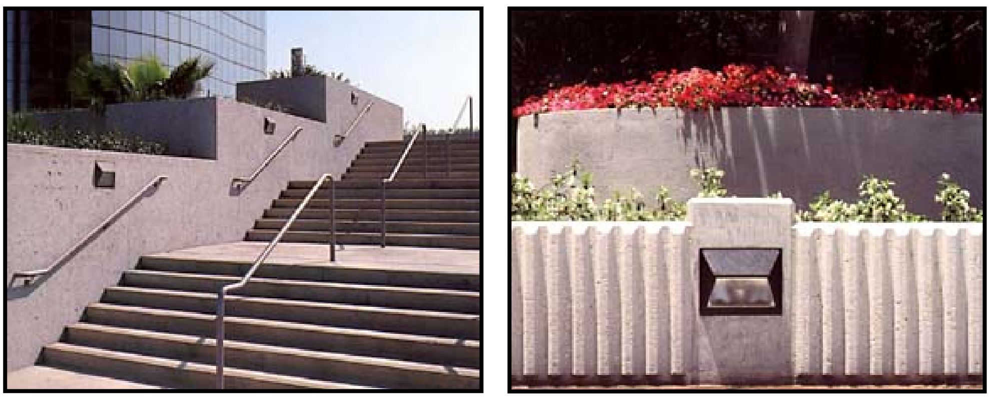

Figure 3.14. Step/Wall Light
(Source: http://www.afcee.brooks.af.mil/dc/dcd/land/ldg/s16 ExteriorLighting/c03Guidelines)

- Walkway and plaza lighting is provided by fixtures mounted at average heights between 3.5- 4.5 meter and is used to high primary pedestrian walkways, plazas and other gathering areas, such as commercial and community centers. These fixtures generally should provide higher lighting levels and a broader light distribution than low-level lighting, are still in proper scale with the pedestrian environment. (L. 2001, p.98) Pole-mounted lighting fixtures for pedestrian and bicycle pathways throughout a park or developed open space area should not exceed 3.5 meter in height and should be spaced in a manner to provide continuous illumination of the pathway. (PZ D&G 2002, p.141) Bollard lighting should consist of low ambient lighting.

-Luminaires:

- The lamp used in low-level lighting is generally incandescent, which typically provides low illumination in a small distribution pattern and is relatively short-lived. For these reasons, the use of low-level lighting should be minimized because of their susceptibility to damage and vandalism.
- For the walkway and plaza lighting, metal halide lamps are recommended because they provide good color rendition and are relatively lived. The use of globe-type luminaries that cast light upward and outward as well as downward should be minimized because of their reduced efficiency. (Bommel&Boer 1980)

-Illumination Levels: The standards and practices to be adopted in a development of a lighting scheme for the pedestrianised routes and spaces are contained in the following publicitations.

- BS 5489: Part 9: 1996- Road lighting code of practice for lighting for urban centers of public amenity areas.
- BS 5489: Part 3: 1992 Road lighting Code of practice of subsidiary roads and associated pedestrian spaces

A general ‘ white light’ policy is proposed for pedestrian paths. Because “white light” (metal halide) improves safety through an enhancement of color rendition and visual recognition. It also helps to distinguish quality spaces. According to these publications, the illumination levels for the general pedestrian areas should be proposed, as presented in the table 3.1.

Table 3.1. Illumination levels of pedestrian spaces

Spaces/ routes	Average illuminance	Minimum illuminnace
Main pedestrian routes	20 lux	10 lux
Shared use vehicular / Pedestrian routes	25 lux	10 lux
Main parkland/ landscape Pedestrian routes	20 lux	10 lux
Secondary parkland/ landscape pedestrian routes	5-10 lux	1-3 lux
Service routes	20 lux	10 lux

(Source: P&Z DG 2002, Gionet 1988, Wood 1997)

3.2.3.2. Playing Fields Lighting

Where playing fields or other special activity areas are to be illuminated, lighting fixtures should be specified, mounted, and aimed so that their beams fall within the primary playing area and immediate surroundings, so that as little direct illumination as possible is directed off the site. Outdoor recreation areas such as ball field and tennis courts should be provided with adequate lighting.

-Design: Lighting of these areas should be designed to ensure continuous and evening lighting of the total field of play. All outdoor recreational lighting should be located and designed in a manner so as to direct lighting to remain within the property line of the facility and to minimize glare and light trespass in adjoining areas. All lighting fixtures should have fixture cut-offs and optically controlled luminaires at the boundaries of the property. Outdoor recreational lighting should have automatic shut-off mechanisms set to turn lights on and off. (IESNA 2000, p. 20-10)

-Luminaires: The lighting source for all outdoor recreation facilities should be limited metal halide in order to ensure better and more accurate lighting. In the event new fixture technology becomes available, consideration should be given to the use of such technology. (Liebl 2003, p.15)

3.2.3.3. Sport Lighting

Sport facilities, such as golf driving, football with grass or artificial surfaces, are often located in an urban fringes or residential area, where surrounding brightness are low. “All sports lighting produce some stray light on adjacent properties.” (Stranks & Berry 1995, p.13) Any quantity of lighting for sports use needs careful consideration.

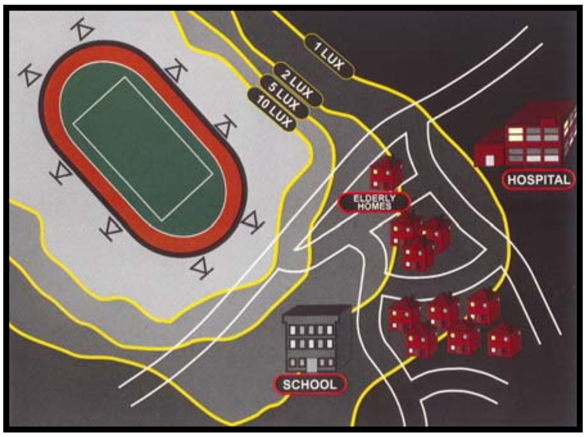

Figure 3.15. Spill and glare from sport lighting on residential amenity.
(Source: Stranks&Berry 1995, p.13)

-Design: Sports lighting can be a challenge to design, particularly if the stadium has to be broadcast capable. “Professional sports require huge amounts of vertical illumination to make the ball visible to the cameras. In these kinds of artificial lighting installation, light trespass onto adjacent areas is very common. This is acceptable, given the fact that such illumination is temporary and is switched on for only about 3 or 4 hours at a time.” (YTÜ Kentsel Tasarım Çalışma Grubu 1992, p. 356)

The main lighting of the facility (spotlighting or floodlighting, etc.) should be turned off no more than 1 hour after the end of the day’s activities or event. A low level lighting system may be installed to facilitate patrons leaving the facility, cleanup, night-time maintenance, etc. (LPAG 1997)

-Height: "The maximum height of outdoor lighting for recreational facilities such as basketball, volleyball, handball, horseshoes, lawn bowling; shuffleboard and bocce ball courts should not exceed 75 meter, measured from the finish grade to the top of the lighting fixture." (IESNA 2000, p.20-8)

-Luminaires: These areas require a high level of lighting, with a minimum of 20 foot-candles recommended. Mercury vapor or high-pressure sodium lamps mounted 9-15 meter in height are recommended. Luminaires should focus the light onto the playing surfaces and prevent light or glare from intruding into adjacent areas. (IESNA 2000)

-Illumination Levels: Lighting levels used for night sports are the highest commonly encountered in the nighttime environment. Recommended levels for social or recreational sports, including most municipal sports activities, range from 200 to 500 lux (20 to 50 footcandles); levels for professional play with large spectator attendance and television coverage can reach 3000 lux (300 footcandles). Controlling trespass and glare with such lighting levels is an extreme technical challenge, requiring the utmost in quality luminaires and design. (IESNA 2000,YTÜ Kentsel Tasarım Çalışma Grubu 1992)

- **Football field lighting**

Football is a sport that combines aerial and ground play. The entire playing area must be uniformly illuminated. To reduce glare floodlights must be aimed out of the line of sight of the players. The proper arrangement of poles minimizes any direct glare for players. The recommended pole quantity varies from 6 poles when located close to the sidelines and 3 poles when located away from the sidelines.
(Kentsel Tasarım Kılavuzu 1992, p.357)

- **Tennis courts lighting**

Tennis courts lighting is similar to football lighting. Using number of poles are less than football lighting because of the small playing area according to football areas.

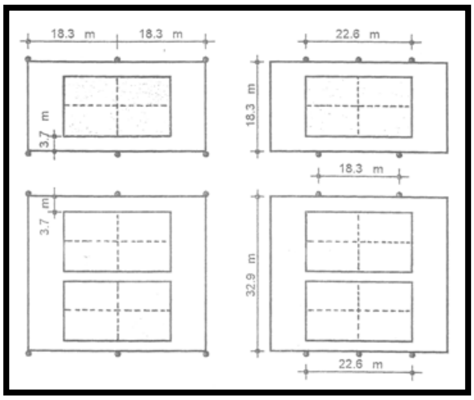

Figure 3.16. The lighting arrangements for tennis courts
(Source: YTÜ Kentsel Tasarım Çalışma Grubu 1992, p.357)

3.2.4. Roadway Lighting

Roadway lighting is a special case of area lighting, and it is often approached in lighting ordinances differently than other lighting. The primary purpose of roadway lighting is to increase the safety and facilitate the flow of night-time traffic by increasing visibility of the road and of the potential risks.

IESNA focuses on “the proper use of the roadway lighting as an operative tool provides economic and social benefits to the public including:

- “Reduction in night accidents and attendant human misery.
- Prevention of crime and aid to police protection.
- Increase in roadway capacity and facilitation of flow of traffic.
- Promotion of business and industry during night hours.
- Inspiration for community spirit and growth.
- Saving of accident costs and lost working time.” (IESNA 2000, p.20-1)

On the other hand, national concern has been continued to be focus on energy. Its consumption, its conservation and its costs are now an integral part of engineering and technical design making.

The design of roadway lighting installation is a process of utilizing known or specified photometric characteristics of selected lamp-luminaire combinations. (Erçetin 1999, p.56)

-Design: There are five basic conventional arrangements. These are:

- "Single sided. All the luminaries are located at one side of the road.
- Staggered. Here the luminaries are placed alternately on either side of the road in a so-called zig-zag fashion.
- Opposite. The luminaries are placed opposite one another.
- Spanwire. In the spanwire arrangement the luminaries are hung from the cables strung across.
- Twin Central. This arrangement is intended for dual carriageways, the
- luminaries being mounted on T-shaped masts." (Bommel&Boer 1980, p.228)

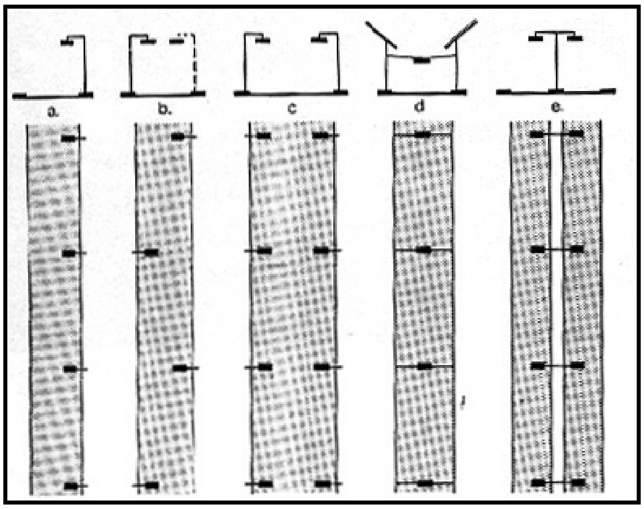

Figure 3.17. The five basic conventional road lighting arrangements: a) Single sided b) Staggered, c) Opposite, d) Spanwire, e) Twin-central (Bommel&Boer 1980, p.229)

In most communities, roadway lighting is specified by engineering standards. Such standards include technical requirements such as average illuminance and uniformity, specific luminaries, mounting heights, pole spacing and location relative to roadsides, curbs or sidewalks, overhangs, lamps type and wattage. (IESNA 2000)

"Luminaire mounting height, dependent in the first place on the lighting arrangements and effective road width has an important bearing on the cost of the installation and the degree to which its often maintenance will be facilitated. Luminaire or column spacing for a given lighting arrangement and luminaire light distribution is dependent on the mounting height and the longitudinal uniformity planned for the installation. On the other hand, the amount of luminaire overhang serves to determine the effective width of the road and thereby the minimum mounting height required for the luminaries." (Bommel&Boer 1980, p.234) These are the important for the roadway lighting design.

Roadway lighting should be used to reinforce the vehicular circulation on the installation by helping to visually differentiate between primary, major and minor streets. The general principles and installation design recommendations should be like on the table 3.2 and table.3.3

Table 3.2. Basic geometry and light output systems

Lantern Type	***Lighting for group and type of traffic route***	***Maximum dimensions (m) where H is the mounting height (m)***			
		Overhang/ A	***Spacing/ S***	***Effective Width/ W***	***Min light flux lower (lumens)***
Cut-off	*A1. Principle (Important roads)*	0.25H	3H	1.5H	$86H_2$
Semi-cut-off	*A1. Principle (Important roads)*	0.25H	4H	H	$108H_2$
Cut-off	*A2. Normal (Main roads)*	0.25H	3.2H	1.6H	$75H_2$
Semi-cut-off	*A2. Normal (Main roads)*	0.25H	4.4H	1.1H	$97H_2$
Cut-off	*A3. Minor (Less important through roads)*	0.25H	3.4H	1.7H	$65H_2$
Semi-cut-off	*A3. Minor (Less important through roads)*	0.25H	4.8H	1.2H	$86H_2$

(Source: AASTHO 1984, p. 27)

Table 3.3. Installation Design Recommendations for Cut-off and Semi-cut-off Lighting on Traffic routes

Arrangement	Mounting height (H) (m)	Cut-off 7	Cut-off 9	Cut-off 11	Cut-off 13	Cut-off 15	Cut-off 17	Cut-off 19	Cut-off 21	Semi-cut-off 7	Semi-cut-off 9	Semi-cut-off 11	Semi-cut-off 13	Semi-cut-off 15	Semi-cut-off 17	Semi-cut-off 19	Semi-cut-off 21
Single side	10	34								47							
	12	42	38								53						
Single central, single carriageway	10			35	35	32	28						47	44			
	12				42	42	41	36					47	44			
Staggered	10	32	30	25	21	18	16	14		44	44	44	37	32	28	25	
	12			36	30	26	23	21	19				53	46	41	37	33
Opposite, or off-set opposite	10					35	32	29					50	50	50	50	
	12						42	41	37						60	60	60
Twin central, dual carriageway (width between kerbs is per carriageway)	10	34	27							47	37						
	12	42	38	31						56	53	43					

Widths between kerbs (m); Design spacing (m)

(Source: AASTHO 1984, p. 28)

-Luminance: Standard horizontal luminance is 15-30 lux for city roads and town center roads. For the roadways illumination, high vertical mounting of luminaries is important to provide required light distribution and mounting height of fixtures should be typically 8 to 12 meter above the ground. (Bommel&Boer 1980, Erçetin 1999)

-Lamps: Roadway lighting generally uses lamps from the gas discharge family. These lamps include high-pressure sodium, low-pressure sodium, metal halide and mercury vapor. High-pressure sodium lamps are the most commonly used light source for roadway lighting. Low-pressure sodium lamps also have high lamp efficiency; however, these do not have as long an operating life as high-pressure sodium or mercury vapor lamps. Metal halide lamps have found only limited use because of their relatively short lamp life. Mercury vapor lamps offer an exceptionally long operating life, but have a lumen efficiency only about half that of high-pressure sodium lamps. (IESNA 2000; Bommel&Boer 1980)

-Location: "The physical roadside conditions may restrict the placement of lighting poles. It is desirable to place poles outside the roadside clear zone whenever practical. Pole locations should consider the hazards in servicing the lighting equipment." (AASHTO 2001, p.10)

3.2.4.1.Interchange Lighting

It is important to reveal all the complexes and features of the entire scene, allowing the driver to know with certainty at all times his position and where he is going. The critical sections are points of access, curves; ramps that need higher level illumination.

Recommended lighting configurations for a selection of commonly encountered road junctions with different symbols are used as shown in figure 3.18. (IESNA 2000)

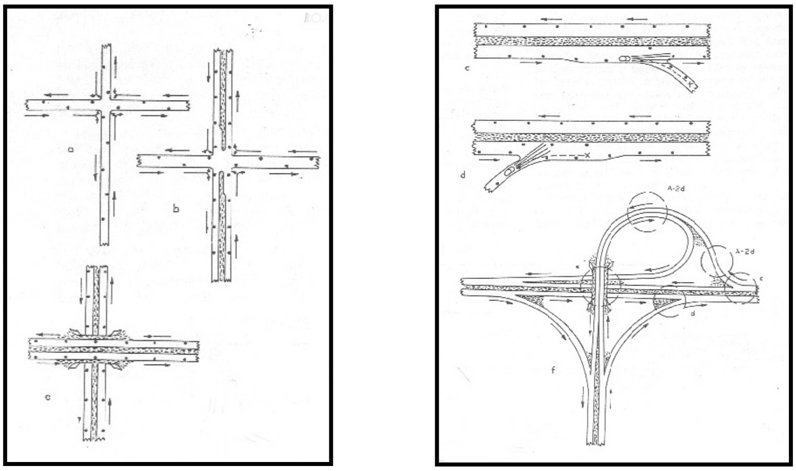

Figure 3.18. Roadway complexities. a) Grade intersection, balanced heavy traffic. b) Larger, more complex grade section c) Diverging traffic lanes, d) Converging traffic lanes, e) Underpass-overpass, f to j) traffic interchanges. (IESNA 2000, p.20-9)

Illustrations are not to scale; these are examples only for guidance as to luminaire location. Pole location should depend on local practice and physical conditions of the area.

3.2.4.2. Parking Lots Lighting

An effective illumination of outdoor parking lot can attract customers to retail establishments, promote traffic and pedestrian safety, deter crime and vandalism and create a sense of personal security. In addition to selecting efficient light sources, energy efficient parking lot lighting must provide proper light distribution. In general, parking areas should have less illumination than their surrounding commercial uses.

-Design: The design standards should be as follows:

- Parking lot luminaries should efficiently direct the light to the parking surface.
- Illumination off-street parking areas should be arranged so as not to reflect direct rays of light onto adjacent streets or properties. (IESNA 2000)
- The alignment and spacing of fixtures in parking lots should follow a regular pattern that is coordinated with the orientation of buildings and other site elements.
- Lighting poles should be incorporated within raised planting areas wherever possible to avoid damage from vehicles and plows.
- Fixture heights should vary with the size and position of the lot. Small or large parking areas should have a maximum pole height of 6 meter unless higher poles will reduce the total number necessary in a large parking lot.
- Al lighting fixtures serving parking areas should be cut-off fixtures.
- The minimum uniformity ratio for exterior car parks is 0.2.
- The use of metal halide lamps is strongly recommended in parking lots. The recommended level of lighting for car parks in rural areas is 5-15 lux and for urban areas is 10-30 lux. **(**YTÜ Kentsel Tasarım Çalışma Grubu 1992, Bommel&Boer 1980)

3.2.4.3. High Mast Lighting

The term of high-mast lighting is generally used to describe lighting in which the luminaire mounting height is 20 meter or more. The luminaires normally being mounted several to a mast to give the necessary degree of light coverage. High mast lighting is used principally on complex junctions on main roads, motorway interchanges, large open spaces such as public car parks or rest areas. According to AASHTO, the mounting height of high mast lighting varies from approximately 20 meters to 55 meter or more. (AASHTO 1984)

“The principle attraction of high mast lighting in such applications is that it leaves the lighted area almost free of columns and so gives the road user an uncluttered view of the road junction and its exists. Glare is also often less of a problem with this form of lighting, even when the junction involves a difference in height between roads, for the luminaires themselves can be placed virtually out of sight by careful sitting of the lighting masts. Maintenance can often be carried out without having to disturb the traffic flow.” (Bommel& Boer 1980, p. 243)

3.2.4.4. Tunnels and Underpasses Lighting

“The term of ‘tunnels’ as used to passageways 300 meter or more in length. ‘Underpasses’ are less than 300 meter long. Tunnels are also the areas whose lighting must be planned by taking great care. Luminance of ceiling and sidewalks may be of equal of greater importance than roadway illumination. The decision whether a tunnel or underpass has to be lit in the tunnel and the traffic density.” (IESNA 2000, p.20-11) Fundamental objectives to be considered are;

- adequate, comfortable driver visibility both by day and at night;
- quality and design of illumination which will minimize driver apprehension and uncertainty
- elimination of distracting and uncomfortable flickering headlights and shadows;
- satisfactory eye adaptation of motorists entering during the daytime, especially under bright sunlight conditions
- dependability of the lighting system, reasonable initial and maintenance costs
- ease and safety in maintaining the system plus minimum interference with traffic flow
- At night, eye adaptation in entering and leaving a tunnel usually is aided by lighting a 500 to 600 foot section of the approach roadway to a level of approximately 50 percent of the average illumination in side the tunnel. (IESNA 2000, Bommel&Boer 1980)

3.2.5. Historical Area Lighting

Outdoor lighting of historic buildings is important It should be compatible with the existing architecture of the area and it uses on designs that minimize light pollution and maximize energy efficiency. Outdoor floodlighting can achieve dramatic effects. With appropriate permission, floodlights can be attached to nearby street lighting poles rather than to the building itself. They can even be installed around the building, flush with the ground surface.

“Lighting designs should enhance one’s ability to interpret the historic character of the areas. Illumination should be accented architectural details, building entries, signs and illuminated sidewalks.” (Şerefhanoğlu 1991, p.92)

“The lighting for historical area is primarily concerned with the material effect that an installation may have upon the external appearance of the buildings; that is the visual impact of the fittings, wiring, conduits, etc. Not only most the physical parameters and visual impact of the equipment be considered, but the illumination produced by the installation must complement the structure, and not detract from the character and appearance of its setting, particularly in conservation areas.” (Stranks&Berry 1995, p.31-32)

“One of the important factors is the selection of the illumination color. Different facade materials require to use of the different light colors; for instance, metal halide and mercury vapor lamps should be used for white marble, clear and sodium pressure lamps that has of color yellow should be used to illuminate buildings built with soil and red brick.” (Menteşeoğlu 2001, p.68)

Before the illumination approach will be defined, architectural buildings, monuments or buildings surrounding and its social effects should be analyzed. Especially, the day appearance of monument or building is important for the designer of illumination. Moreover, another factor is where the lighting device is located.

3.2.6. Illumination of Urban Values (Features)

The illumination of features involves using direct or indirect lighting to accentuate features or create a special effect. This differs from vehicular and pedestrian lighting, which involve using direct lighting safety, security and general area illumination.

3.2.6.1. Building Facade Lighting (Architectural)

Facade lighting is a way of highlighting special architectural features. Lighting used to illuminate building facades should be limited to areas where it enhances particular features in accordance with the overall lighting plan.

Figure 3.19. Illuminated of Vakıfbank building in İzmir. (Source: Philips 2002)

- Lighting fixtures should be properly sited, aimed and shielded so that light is directed only onto the building facade.
- Maximum level of illumination should not exceed 50 lux. (IESNA 2000)

Common practices for building floodlighting use up-directed luminaries that project a large proportion of their light directly into the sky. The floodlighting should be installed as given in Figure 3.11.

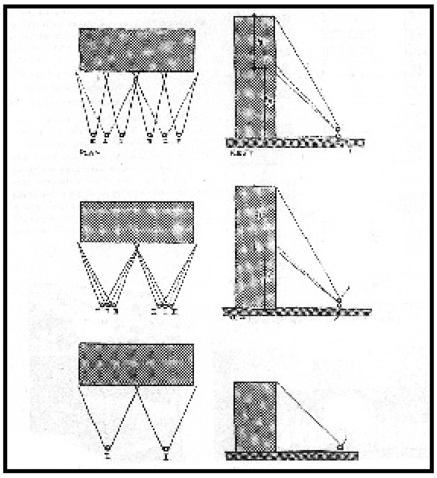

Figure 3.20. Building Floodlights (Source: Boduroğlu 2001, p.131)

The facade of the building is lit up, but some of the light is lost upwards. Whenever possible, the light should be directed downwards. The recommended lighting elements should be lighting refractors, screens and asymmetrical optics be used as these aim the light flow onto the surfaces of the building and minimize the loss of light. (Iguzzini 2000)

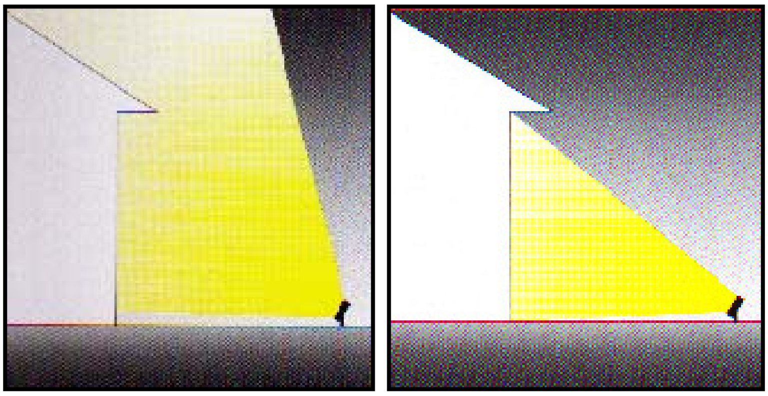

Figure 3.21. The facade lighting aimed upwards (Source: İguzzini 2000, p.15)

The lighting is aimed downwards, but the lens is nevertheless loosing some light upwards because of the excessive angle of the fitting. The use of asymmetrical optics enables a perfect illumination whilst the excessive angling of the other fixtures. (İguzzini 2000, p.15)

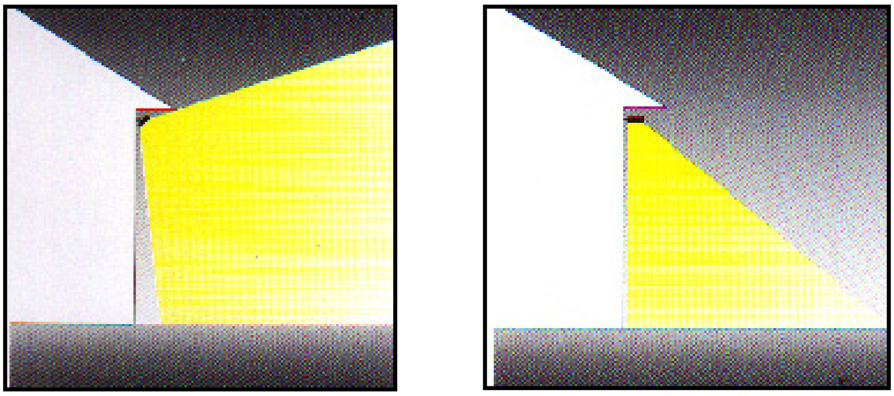

Figure 3.22. The facade lighting aimed upwards (Source: İguzzini 2000, p.15)

3.2.6.2. Landmarks Lighting

Illumination can be an effective tool to highlight landmarks and focus attention, which can also assist with nighttime orientation. However, care should be taken not to overuse landmark lighting, which may weaken its overall effectiveness and waste resources.

▪ "Installation entry areas, monuments, static displays, architectural landmarks, and other such features should be lighted with floodlights or spotlights, creating patterns of light and shadow.
▪ The lamp should be directed away from viewers, and, if possible, the light fixture should be hidden.
▪ Lighting attached to buildings should be minimized and generally confined to entries." (Denver 1997, p.45)

3.2.6.3. Landscape Lighting

Landscape lighting achieves special effects by controlling the type, intensity, and direction of light to accent a landscape feature. Several basic lighting effects can be used to accent landscape features. Some important guidelines;

▪ It should be properly sited, aimed and shielded so that light is directed only onto the selected tree or shrub.
▪ Conceal the light source behind shrubs, etc., where possible - except where the fixture itself is a decorative element.

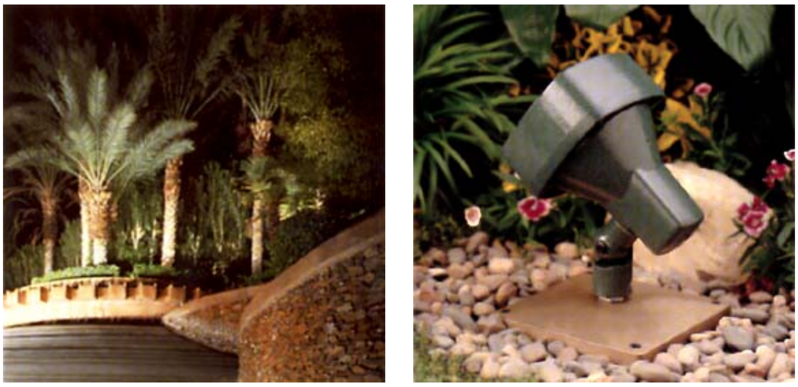

Figure 3.23. Landscape lighting
(Source: http://www.afcee.brooks.af.mil/dc/dcd/land/ldg/s16 ExteriorLighting/c03Guidelines)

▪ Be creative in using a mixture of lighting techniques for drama and excitement
▪ Arrange for an automatic device to turn lights on and off, such as a timer or photocell. (LPAG 1997)

There are many lighting techniques that beautify landscape. These are given in Figure 3.24.

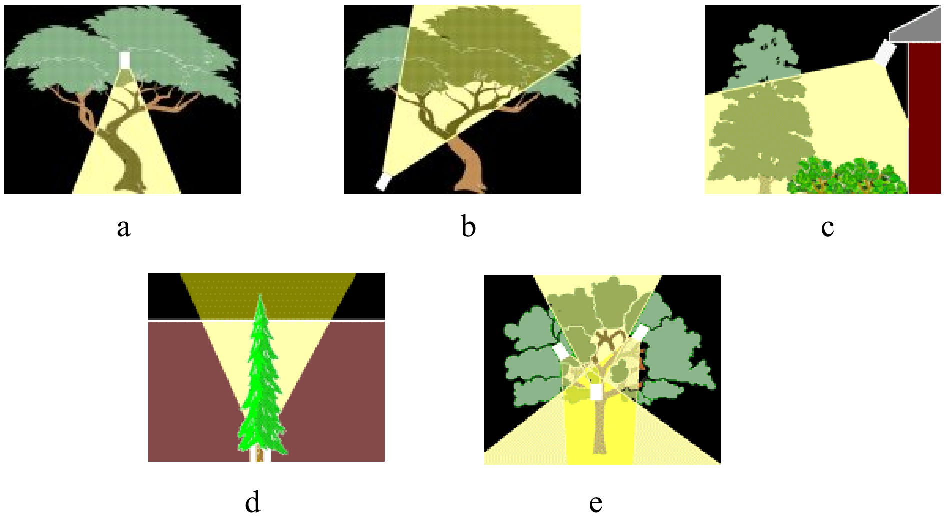

Figure 3.24. Lighting techniques a) Down lighting; b) Uplighting; c) Floodlighting; d) Back lighting; e) Moonlighting (Source. http:/ vistapro.com)

Spread lighting produces patterns of concentric circles of light downward for illuminating flowerbeds, low shrubs, and ground cover.Path lighting is basically spread lighting but at a lower height. This technique of lighting is ideal for illuminating pathways, borders, steps, and driveways. In this type of lighting, a high degree of light shielding is necessary to prevent glare. Down lighting is that the most common and efficient technique for creating the effect of sun- or moonlight is to use concealed light sources placed on poles, buildings, trees, or any other high structure and aimed straight down to highlight plant material or create patterns on surfaces to bring out their texture.

Subtly lighting the background wall, fence, or rocky hillside allows plants to be seen in silhouette. This technique is recommended when the density and shape of plant material can clearly be seen -- as in a sunset effect. Backlighting also can be effectively used as security lighting. (http:/ vistapro.com)

Floodlighting is that placing light fixtures on buildings, poles, trees, underwater, or in the ground is the most common technique for general illumination. As with uplighting, however, proper placement and aiming of fixtures and lamps is critical for effective results. Moonlighting is a very effective and attractive effect that is achieved by positioning the lighting fixtures high above the ground to simulate moonbeams filtering through the branches.

Landscape lighting reveals the building and grounds in the setting that is lost as night fell. The purpose of lighting is to re-establish the relationship between the building and the landscaping. Lighting should enhance the setting, extend the hours of enjoyment of the outdoors and provide for the safety and convenience of guests. It can also address issues of security in a manner that is aesthetically pleasing and appropriate to the site. It is therefore important that the lighting be appropriate to the landscaping

3.2.6.4. Bridge Lighting

Bridge aesthetics are an important design consideration for all bridges. The design of the light takes advantage of the architectural qualities of each bridge. "Whenever the bridges presents these qualities are enhanced; but when little architectural value is present the bridge will be transformed into a lighting sculpture. Low glare lights and fiber optic tubes should be used to minimize glare and ensure public safety. The link between bridges should be visual". (C. C. C. 2000) A key issue of bridge lighting systems is the ability to maintain such systems throughout the life of the structure.

Figure3.25. Gateshead Millennium Bridge**,** River Tyne, England
(Source: http://archrecord.construction.com/features/bwar Awards/archives/02gateshead.asp)

"Lamps, or light sources are usually designed using flood lights that have specific beam patterns and/or shielding to give the desired effect. Fixtures are generally either high-pressure sodium or metal halide type luminaries. High-pressure sodium lamps are generally less expensive than metal halide lamps and can be distinguished from metal halide because of their golden glow. Colors other than white or gold can be achieved by adding lenses to the fixtures.” (FDOT, www.dot.state.fl.us/Structures/botm/bridgelighting/lighting.htm)

Figure 3.26. Illumination of Anzac Bridge (Source: Philips, Issue No:8 2001)

3.3. Evaluation of Turkish Outdoor Lighting Regulation

Turkish outdoor lighting regulation has been prepared by Minister Energy and Natural Resources. However, it is not valid regulation. Its aim is to provide energy conservation with using efficient energy and prevent light pollution. This regulation consists of five parts. These are:

- Definitions about lighting and terms concerning urban planning
- Basic principles including lamps and luminaries
- Illumination districts
- Certification of lighting projects, application and inspection
- Judgments regarding validity

The purpose of the regulation is to show how lighting design for types of roads can be approached in a coordinated way. Such an approach is to minimize cost and increased efforts to conserve energy.

After the first definitions, the second section clarifies lamp and luminaries principles for application. These explanations are based on the design solutions regarding implementation areas. However, in this examination, there is a contradiction between foreign countries regulation and Turkish. Metal halide is common light source for residential areas, but Turkish regulation proposes that this type can be used only sport facilities. This is an important difference.

The third part examines the illumination districts. This zoning is related with proposed illuminance flux. These are:

- District I: surroundings of observatories
- District II: Villages and urban fringes
- District III: Urban areas
- District IV commercial and touristic centers.(Appendix B)

The last part gives information about application stage as follows:

- Approval of lighting projects that must include the followings
    - Lamp and luminaire types and their locations
    - Technical data about their photometric curves, diagrams of luminances, glare curves etc.
    - Calculations of proposed lighting design
    - Schemes of electricity.
- Application and inspection

The regulation is more related to principles of lighting installation (Appendix B). Outdoor lighting criteria are given to provide comfort and safety& security principles for different types of roads and illustrated in tables. However, determined classifications are not clearly understandable; because the classifications are complicated. Also illumination levels in respect to this classification are not appropriate for providing an effective illumination at night-time. For example, illuminance levels –especially pedestrian ways are proposed at lower level according to standards of the foreign countries as 1.5, 3 and 5 lux as shown in Table 3.4.

Tablo 3.4. Proposed illumination levels for different types of pedestrian areas

Category of roadways	Level of average illuminance (lux)
P1	20
P2	10
P3	7.5
P4	5
P5	3
P6	1.5

(Source: Turkish Outdoor Lighting Regulation, Appendix B)

Consequently, some deficiencies are determined after examination of the regulation. In this regulation, there is no information about the equipment placement and spacing. Therefore, the common systems are not illustrated uniform systems. The regulation concept is lack of improving urban identity and image. It is based on only roadways. However, proposed information is not enough to create an effective and an attractive design. Also, land use decisions are not clearly taken into consideration. In spite of deficiencies, this regulation is important to systemize outdoor lighting projects. It should be upgraded to achieve the best-illuminated night-time environment.

3.4 Evaluation

This chapter has attempted to examine to land use provisions related to outdoor lighting by incorporating current concepts and improving lighting results throughout the city plans and applications. It describes the requirements for outdoor lighting that are applicable for projects undergoing site plan. As a result, the outdoor lighting principles and requirement should be based on land use designation and urban features.

As shown the literature survey, the lighting approaches are generally based on pedestrian and drivers. The needs differentiate between drivers and pedestrians. Table 3.4 shows the main differentiations for them.

Table 3.5. The main criteria of traffic lighting and pedestrian lighting

Lighting for Traffic	**Lighting for Pedestrians**
Good horizontal illuminance	Good vertical illuminance
High uniformity	Low uniformity= high visual interest
High mounting heights (8-12m)	Human scale mounting heights (3-5 m)
Poor colour rendering	Good colour rendering

The other important point is that the quality of the outdoor lighting is more closely related with parameters like the amount of illumination. Recommended levels of illumination that provide an effective and an efficient night-time environment are given in Table 3.5.

Table 3.6. The recommended illumination levels

Area/Activity	Lux
Roadways	15-30 lux
Main Pedestrian Ways	10-20 lux
Shared use Pedestrian / Vehicular	10-25 lux
Service Routes	10-20 lux
Parking Lots	10-30 lux
Parks	10-20 lux
Sport Facilities	200-500 lux

Recommendations

- Adopt the hierarchy of light levels based on land uses, crime rate and urban design policies
- Develop suitable standard of outdoor lighting for use throughout the urban settlement.
  - ✓ Require utility wires for streetlights be undergrounded
  - ✓ establish new streetlight pole standards,
  - ✓ specify criteria for lamp fixture choice;
  - ✓ adopt lamp technology, color rendering and light spectrum;
  - ✓ reevaluate night-time safety criteria,
  - ✓ establish ongoing streetlight planning

- ✓ reconsider night-time safety criteria.
- Develop a comprehensive detailed outdoor lighting master plan and ordinance ongoing public and private outdoor lighting efforts.
- Streetlight and outdoor lighting plans and programs should be reviewed and updated on a regular basis. Especially cost of streetlight plans and maintenance are essentially needed.

Consequently, for outdoor lighting, there are different visual needs and demands according to the functions and services should be provided at certain areas.

CHAPTER 4

CASE STUDY: ASSESSMENT OF THE URBAN OUTDOOR LIGHTING QUALITY In RESIDENTIAL AREAS

In this chapter, quality of outdoor lighting installations is examined. In order to measure the lighting quality in İzmir, existing lighting arrangements are observed. Therefore, this chapter is carried out in five sections. In the first section (4.1), this study has undertaken detailed observations of outdoor lighting practices in İzmir. Outdoor lighting installations concerning functions and activities have been observed. This section also indicates current illumination characteristics of public outdoor spaces in İzmir in respect to their techniques and standards determined in the previous chapters. By this way, it may be pointed out that "existing residential areas are not so well illuminated as the other public outdoor spaces".

The second section (4.2) presents an overview of the analytical phases which are described in detail within the context of both quantitative and qualitative data as follows:

- Data collection (Field survey)
- Cost analysis
- Analytical Hierarchy Process (AHP) by using Expert Choice Software.

The third section (4.3) includes data collection related with technical information on the existing system depending on both night and day observations. The fourth section (4.4) presents calculations concerning costs of existing conditions of residential areas and comparison of them. In the fifth section (4.5), application of Analytical Hierarchy Process (AHP) is carried out in order to evaluate this comparison of the existing conditions of the residential areas. This method is mostly based on interviews with residents and local experts; as a result, the results are evaluated in reality. In addition to the evaluation by using AHP, these results are used for specifications of the criteria and assessments.

Consequently, the selected residential areas have been examined in terms of existing lighting systems. These have been compared with the each other regarding human needs, functionality, economy and facilities. Thus, this study indicates that “high quality illumination of residential areas may be provided with well-designed lighting plans and regular maintenance”. Moreover, the current illumination installations should be upgraded and redesigned.

4.1.The Current Illumination Characteristics of Public Outdoor Spaces in İzmir

İzmir city has a relatively a large residential population of 3.3 million approximately. Population density is also high and growing up. Beside that, man-made environment has been subjected to uncontrolled development and rapid changes which give rise to the loss of urban identity. Because of this, life quality of the residential areas is needed to be improved. Therefore, the outdoor lighting as a component of the built environment is an important factor in the improvement of the quality of life in residential areas.

Outdoor lighting has slowly become an integral part of night-time in İzmir. Recently, İzmir metropolitan municipalities have funded lighting (poles, new wirings, fittings and electric power) of public spaces such as streets, pedestrian areas and other public facilities and certain active open areas. Parallel to the development in lighting, there is also a growing discussion among lighting professionals about trends in outdoor lighting’s use and the impacts of those trends.

Figure 4.1 İzmir nightscape

İzmir‘s night-time environment may be characterized by a visible demonstration of inconsistent outdoor lighting. In many cases, especially in residential areas, current lights have been placed on inappropriate spaced poles with fixtures having poor optical controls. The lack of optical controls on these fixtures has created light trespass, sky glow and glare. Glare is a common outdoor lighting condition in İzmir, discomforting drivers and pedestrian eyes.

Figure 4.2 The existing installation causes the light trespass in Narlıdere.

Light trespassing into buildings and uplighting to the sky are the other characteristics of the degraded night-time environment. Due to the light trespassing, lamps installed with outdoor luminaries are generally damaged by residents.

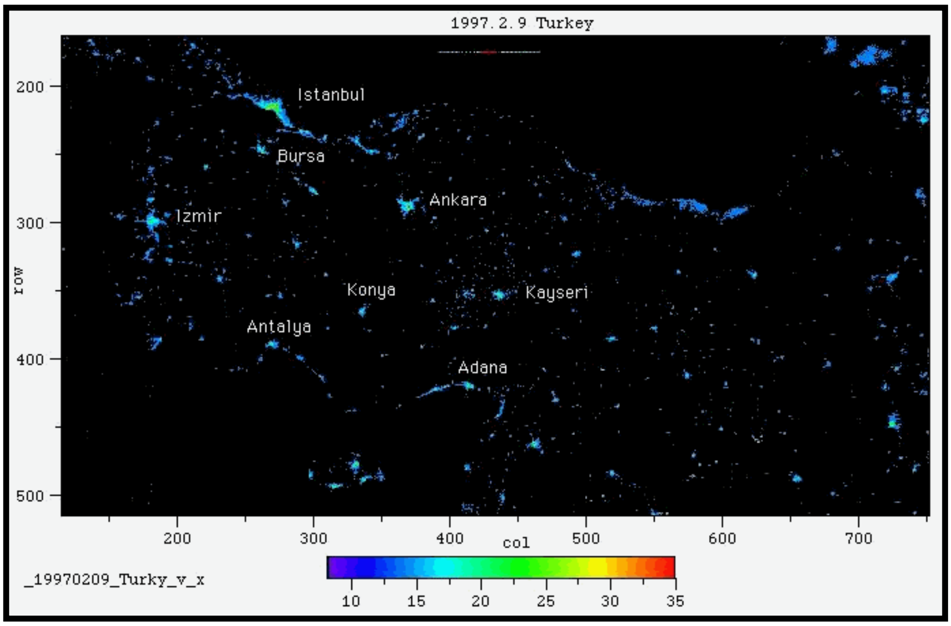

Figure 4.3. Light pollution level for the cities in Turkey

As it may be seen in Figure 4.3, İzmir and Ankara have similar level of light pollution which is less than that of İstanbul city.

Table 4.1. The energy and the loss of the light energy perceived DMSP at 1997.

City	Observed Worth (10^8Watt/cm^2/day)	The Loss Of Light Energy (10^8kWh/year)	Area (km^2)	Loss Of Energy/Area (10^8kWh/km^2)
İstanbul	**2,27 x 10^3**	**13,6**	**2808**	**4,85 x 10^3**
İzmir	**5,58 x 10^2**	**3,34**	**1086**	**3,08 x 10^{-3}**
Bursa	**2,92 x 10^2**	**1,75**	**739**	**2,37 x 10^{-3}**
Ankara	**1,13 x 10^4**	**6,77**	**1745**	**3,88 x 10^{-4}**
Antalya	**1,89 x 10^2**	**1,13**	**653**	**1,73 x 10^{-3}**
Adana*	**3,31 x 10^2**	**1,98**	**742***	
Kayseri*	**4,51 x 10^2**	**2,7**	**806***	
Konya*	**2,22 x 10^3**	**1,33**	**551***	
Londra	**6,01 x 10^3**	**36**	**3210**	**1,12 x 10^{-2}**
Belfast	**2,10 x 10^2**	**1,26**	**774**	**1,62 x 10^{-3}**
Paris	**8,08 x 10^3**	**48,4**	**4521**	**1,07 x 10^2**
New York (Long Island)	**2,26 x 10^4**	**136**	**9095**	**1,50 x 10^4**
Viyana	**1,20 x 10^3**	**7,19**	**1080**	**6,66 x 10^3**

(Source: DMSP at 1997.

Night-time inspections during this study of residential areas lighting indicated that existing lighting installations contribute to a non-uniform illumination and dark spots along roadways and footpaths. In residential areas, active open areas and parking lots, non-cut off light fittings which have prolonged use have been installed but they provide poor light distribution. Both poor design and inadequate lighting contribute to unsafe locations in public spaces.

The ambient night-time lighting condition in the immediate central vicinity has been created by a combination of lighting types and sources, including street lights, security lighting, illuminated restaurant and other retail business signs, architectural illumination. On the other hand, in the central area in İzmir, a variety of light fixtures currently exist because many of the institutions have implemented their own individual exterior lighting preferences on public streets. The efforts show that the illuminated environment is deprived of the local inspections. According to the other outcome of research in İzmir, there are no standards for lighting equipment characteristics in respect to color, mounting height, pole location, and spacing. Existing arrangements generally differ from in outdoor spaces. Except roadway installations there is no standardizations in different public outdoor spaces. Especially pole locations and spacing do not enhance the urban blocks, corners and building entrances.

Outdoor lighting in İzmir generally involves lighting fittings mounted on concrete, metal or galvanized poles in residential streets, arterial roads, regional roads and in the some public areas (e.g. active open areas and reserves, sports and recreation facilities and pathway facilities). Various types of lighting components form part of this infrastructure, as in the Table 4.2.

Table 4.2. Types of lighting used in İzmir, 2003

Lamp/fittings type	Use
Twin 11 Watt compact fluorescent	Mostly on minor/residential areas
40 Watt fluorescent	Mostly on minor/residential areas
125 Watt mercury vapor	Main and minor roads
110 Watt high pressure sodium	Mostly on main roads
250 Watt mercury vapor	Main roads, sport facilities
210 or 215 Watt low pressure sodium	Mostly main roads
250 Watt high pressure sodium	Mostly main roads
40 Watt incandescent	Pedestrian way, active open areas, parking lots, minor roads,

As may be seen from table 4.2 above, the present outdoor lighting display varieties. The fluorescent and the incandescent lamp types are used the majority of these lamp types in İzmir; but these lamps are not preferred for the outdoor lighting.

The current outdoor lighting infrastructure in İzmir consists of limited light fittings of various types. The majority of existing fittings in the city are provided by “cobra head” streetlights at a height of between 7 meter and 15 meter. The short-arm fluorescent fixtures are mounted on alternate electric poles (spaced irregularly in public outdoor spaces) and in most cases may not be evenly spaced and properly levelled. The globe fixtures have been installed many public outdoor spaces that include minor roads, pedestrian ways, active open areas and parking lots. These cause the light pollution because of non-cut off type light fittings that provide poor light distribution. But the local authorities do not comprehend light pollution.

Figure 4.4. View of Karşıyaka from Yamanlar Mountain, (Source: Zeynel Tunca 1991)

At present, the system design predominant in İzmir is the result of focus on horizontal illuminance solely instead of more effective requirement of both horizontal and vertical illuminance. For traffic route lighting along main roads, the present lighting fittings are "semi-cut-off" type light fittings (with either high pressure sodium or mercury lamps.). The City currently has a streetlight standard of about 10-30 lux. The night lighting in İzmir may be effective for the roadway, but is not effective for pedestrians due to the vertical lighting.

A visual inspection at night in İzmir gives an impression that often the effectiveness of the lighting systems on main roads is compromised due to glare, inadequate vertical illuminance, lack of uniformity and integration posing adaptability problems for motorists. Therefore, the trend of replacing high-pressure sodium lamps (blue-white light spectrum) is generally conductive to night vision. Existing neighborhoods with the cobra head style lighting met the average luminance standard in particular. In some areas, the reconstructions or building of new roads with in the city include streetlights as well as the under grounding of existing overhead utility cables. Because of the installation problem, the under grounding utility of cables may not provide an efficient use of electric power. Therefore, lighting cables are installed between poles located in the streets. As a result, this view generally causes clutter and critique situations.

Generally, urban residential areas in İzmir are deprived of good illumination and maintenance services. Therefore, in residential streets, lighting has often been an afterthought. The power pole came first and the lighting system has been grafted onto this. The situation needs to be addressed a decision for upgrading or redesigning the existing lighting system in residential streets in İzmir.

Figure 4.5 Illumination of residential area in Bornova

The passive and active open areas in İzmir generally are not effectively lit at night. By day, the open areas offer a positive contrast between built form and open space. But by night, they often disappear as districts of darkness within a network of illuminated streets. Thus, the active open areas have not been adequately lighted. Poor lighting or glare impairing the visibility of the pedestrians affects pedestrian safety on streets. Inadequate lighting has been also defined as a problem by residents.

Figure 4.6 The illumination of central park in Bornova

Another important factor in the urban illumination is street trees. Street trees and vegetation enhances streetscape and amenity. However, wrong sitting of trees and unsuitable species, growing into canopies below street light fittings, often block effective light distribution, particularly in minor streets.

Prior to this study, there has been little data on current outdoor lighting conditions and practices in İzmir and even less energy use information on understanding of the extent of good or bad lighting practices utilized. Following an introduction to basic principles of illumination that includes technical criteria and functionality, the existing lighting structures have been observed. In recent times, the design of new public outdoor spaces has changed to eliminate many of the above-mentioned problems. There are new streetscape improvement projects that include lighting in İzmir; for instance, Konak Square, Mithatpaşa Street water front, Mimar Kemalettin Street are the renewal areas in İzmir. However, the majority of residential areas have not equal consideration like boulevards and other public outdoor spaces.

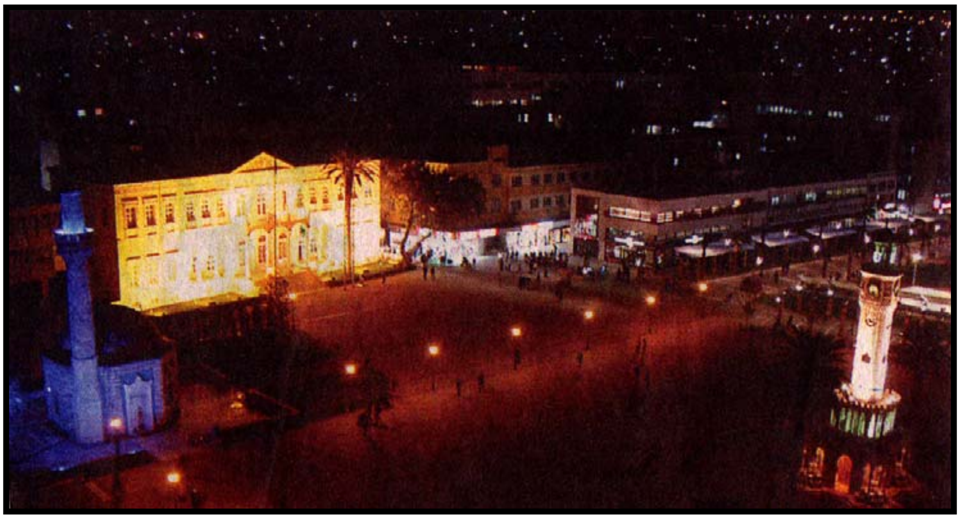

Figure 4.7 Konak Square (Source*:* Hürriyet EGE 2003)

During the observations of urban illumination in different public outdoor spaces, it has been determined that residential areas are deprived of quality lighting principles. Moreover, the “darker spaces” in residential areas are more than the other public outdoor spaces. The results of field surveys proved that the many illumination of residential areas does not include the suitable characteristics considering design, illuminance level, uniformity and visual demands; as a consequence, this study has been organized on urban outdoor lighting quality of residential areas. Especially high-rise multi family residential districts have been chosen to measure outdoor lighting quality. This is because of the fact that a coordinated and systematic lighting may be installed in these areas. The plans may include widespread detail concerning outdoor lighting system regarding as locations, system detail, fixture detail and so on. In conclusion, the existing illumination characteristics, which are in defined boundaries, will help to clarify existing problems and their approaches.

4.2. Analytical Study Phases

The analytical approach about the outdoor space illumination consists of three phases. These are:

1. Data collection that includes field surveys and interviews,
2. Cost analysis
3. The assessment of outdoor lighting quality with the Analytical Hierarchy Process.

The most basic principles for each step will be examined in the following sections.

4.2.1. Data Collection

The data collection includes daytime and night-time field survey. This data from three sites will provide the framework for the design of the outdoor lighting assessment tool. It is expected that for these sites the following data, at a minimum, will be required:

- Visit the site during the day to complete an inventory of lighting equipment.

1. The inventory consists of a digital picture of each type of luminaire with a brief description. If luminaire manufacturer and lamp information is available, this will also be obtained. The data for each luminaire is documented in tables.
2. Make a note how the equipment is installed and if it is levelled properly.
3. Record the type of light source (HPS, metal halide, mercury, incandescent, fluorescent) and wattage estimate.
4. Record the function of uses.
5. Sketch approximate equipment locations and typical dimensions such as pole spacing.

- Visit each site during the night to obtain typical illuminance readings.

1. At a location that is on the property line or off the property, typical illuminance readings are taken with the lux-meter aimed directly at the brightest luminaire. A

hand- held, ITT light meter with a range of 0 to 500 lux has been used to determine readings, obtained at İzmir Chambers of Electrical Engineering. The human eye easily adapts to different illumination levels; but the lux-meter accurately measures those different levels. However digital lux meters are more sensitive more than this one. If a combination of luminaires is on site, typical areas may be measured. Examples are parking lots, pedestrian walkways, façade and landscape lighting, parking areas, roads

2. Provide a subjective expert opinion from each surveyor as to whether the lighting appears "too bright", "bright", "just right", "too dark" relative to the neighborhood and the purpose.

The night-time assessment is important to help determine whether the lighting system as it performs is sufficient, over designed or under designed. An over-designed lighting system is one which the amount of lighting produced exceeds the amount that is required to perform visual tasks at night or produces a lot of glare, which may impede night-time vision. An under-designed lighting system is one that the lighting is not sufficient to perform visual tasks at night.

A documentation of the following issues and characteristics will be prepared for each of the three sample sites using the data collected during the on-site visit:

1. Purpose for outdoor lighting (safety, security, aesthetics, community driven issues, advertising)
2. Activity of the outdoor area
3. Lamp:
    - Lamp type
    - Colour
    - Watt
4. Luminaire:
    - Type
    - Bracket length
    - Spacing
5. Pole:
    - Type
    - Mounting height

- Location

6. Illumination levels
   - Measured lux
   - Levels (Too bright, bright, just bright)

7. Cost
   - Equipment& Installation
   - Energy Cost

To sum up, these are observed according to technical design criteria and layout, as given in Chapter 2.

After the formulation of layout, the results of observations will be handled in three stages that are;

- the design concept
- equipment characteristics
- performance.

- **Design concept** includes general design principles about outdoor lighting installations for the each sample site. This concept will be examined through urban design concept such as aesthetics, integration with other urban element, landscaping, townscaping, pedestrian and vehicular network.
- **Equipment characteristics** including style, pole spacing, color, mounting height, location. This data gives about light pollution, appropriateness for activity.
- **The performance** criterion shows the existing number of equipment and equipment performance measured by lux-meter. This part will be interpreted through observations and measurement.

The designs and evaluations in this study consider three sample areas. It will show the balance between safety, security, appearance and economy.

4.2.2. Cost Analysis

Designers may propose designs that include cost and benefit data and help the client match design solution to design objectives. The cost factors need to be taken into consideration for outdoor lighting policy and decision making are; energy, maintenance, capital cost, economic life of lamps and light fittings. The spread sheet adapted from the "Outdoor Lighting Pattern Book" and an article with the title called "A Simple Cost Estimation Technique for Improving The Appearance and Security of Outdoor Lighting". (1) The financial values have been listed in the tables to use the calculations. The financial values have been obtained from "2003 Elektrik Proje and Tesis Birim Fiyat Kitabı". (2) All costs are based on 2003 TL; inflation or differential price increases in energy costs are not considered.

Each sample site has been evaluated for initial costs, maintenance cost, energy and electricity costs with a detailed calculation. The economic analysis gives cost information for each selected area. The cost data will be converted to square m2 costs. The results will be compared. Thus, the cost coefficients in terms of cost per unit will be determined. In conclusion, the cost coefficients will be summed up to compare with each sample area.

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1. This has been reviewed table in Outdoor Lighting Pattern Book", published by the Lighting Research Center, and an article with the title called "A Simple Cost Estimation Technique for Improving The Appearance and Security of Outdoor Lighting", published by Russell P. Leslie.

2. This has been prepared from "2003 Elektrik Proje and Tesis Birim Fiyat Kitabı", published by TEDAŞ and several manufacturers that are "Globsan, Tekon"

Table 4.3. Total lighting cost worksheet

				Site Name:
	Luminaire Type1	**Luminaire Type2**	**Luminaire Type3**	**Total**
Initial Cost				
A- Luminaire Name				
B- Lamp Type				
C- Number of Luminaires				
D-Cost per Luminaire (Table 4.4)				
E- Total Luminaire Cost (D*C)				
F- Lamps per Luminaire				
G- Total number of Lamps				
H-Lamp Cost (Table 4.5)				
I-Total Lamp Cost (G*H)				
J-Number of Poles				
K- Pole Cost (Table 4.6)				
L- Cost per Arm (Table 4.8)				
M-Total Pole Cost (J*(K+L))				
N- Length of 4*10 NYY				
O- Total cost of 4*10 NYY				
P- Length of 2*1.5 NY+A46				
Q-Total cost of 2*1.5 NYM (Table 4.9)				
R- Total Cost of W Automation				
S-Cost per Photocell				
T- Cost for control panel				
U- Cost for conductor				
V- Cost for electricity meter				
W- Total Equipment Cost				
X- Labor				
Y-Total Installation Cost (N*O)				

Annual Cost				
A1-Average daily use				
A2- Operating time (365*A1)				
A3- Lamp Power				
A4- Energy Use ((G*A3)*A2*1.2)				
A5- Maintenance Cost				
A6- Electricity cost				
AA- Annual Energy Cost(A4*A6)				
BB-Annual Operating Cost (A5+AA)				

A. Enter the names of the luminaire types used in the design, listed in Table A1.
B. Enter the type of lamp to be used in the luminaire.
C. Count the number of luminaries of each type used in the design.
D. Enter the price of one luminaire.
E. Multiply C by D to get the cost of the luminaries.
F. Enter the number of lamps used in each luminaire.
G. Multiply C by F to get the total number of lamps used by each luminaire type.
H. Enter the cost of one lamp.
I. Multiply G by H to get the total cost of lamps for this luminaire type.
J. Count the number of poles used in the design for each luminaire type.
K. Enter the cost one pole,
L. Enter the price of one arm or bracket.
M. Multiply J by K and adding to it the cost for the number of arms or brackets on each pole to get the total cost of poles for each luminaire type.
N. Enter the length of the 4*10 NYY cables
O. Enter the total price of NYY cables.
P. Enter the length of the2*1.5 NYM cables
Q. Enter the total price of NYM cables.
R. Enter the total price of W automation
S. Enter the total price of photocell
T. Enter the total price of control panel
U. Enter the total price of conductor
V. Enter the total price of electricity meter
W. Add E, I, M, O, Q R, S, T, U and V to get the total initial cost of equipment.
X. Consult with your engineer and contractor for installation and wiring costs.
Y. Add W and X to get the total installation cost.

A1. Estimate the average hours of one lamp's operation per day.
A2. Multiply P by 365 days to get the annual hours of lamp operation.
A3. Enter the input power the one lamp
A4. Multiply G by A3, A2, 1.2 that is the loss of ballast to get annual energy use in kilowatt hours
A5. Multiply W by Y to get the annual maintenance cost.
A6. Enter the average cost of electricity in your area.
AA. Multiply A4 by A6 to get the annual cost of energy
BB. Multiply AA by A5 to get the annual cost of energy

Table 4.4 Luminaire cost (Source, TEDAŞ, 2003)

Type	Price *TL*	Fitting Price *TL*	Total Price *TL*
Mercury Vapor			
125 Watt	22.165.000	26.543.000	48.708.000
250 Watt	43.291.000	26.543.000	69.834.000
High Pressure sodium			
125 Watt	42.868.000	26.543.000	69.411.000
250 Watt	56.469.000	26.543.000	83.012.000
Fluorescent			
1*40 Watt	24.194.000	12.976.000	37.170.000
1*20 Watt	17.930.000	12.976.000	30.906.000
2*11 Watt	11.329.000	12.976.000	24.305.000
Globe			
20 or 40 Watt	10.000.000	5.000.000	15.000.000

1 USD= 1.440.000 TL (2003)

Table 4.5 Lamp cost (Source: TEDAŞ,2003)

Type	Price *TL*
Mercury Vapor	
125 Watt	3.874.000
250 Watt	9.875.000
Sodium	
125 Watt (HPS)	16.415.000
250 Watt (HPS)	18.323.000
Fluorescent	
20 Watt	600.000
40 Watt	1.190.000
11 Watt	3.272.000
Incandescent	
40Watt	270.000
Ecotone 32 Watt	6.000.000

Table4.6 Pole (Source, TEDAŞ, 2003)

Pole	Height *meter*	Price *Single Bracket*	Weight *kg*	Price *Twin Bracket*	Weight *kg*	Price *Third Bracket*	Weight *kg*
Concrete							
	7	52.150.000	375	57.980.000	380	68.100.000	400
	8	59.860.000	420	66.280.000	425	78.630.000	445
	9	67.700.000	570	73.540.000	575	86.040.000	530
	10	84.270.000	675	85.340.000	680	93.880.000	670
	11	87.120.000	790	95.130.000	795	111.880.000	775
Steel (Globe)							
	1	46.000.000	-	-	-	-	-
	2.35	95.000.000	-	-	-	-	-
	3	40.000.000	-	45.000.000	-	-	-
	6	-	-	-	-	60.000.000	-
Galvanized							
	5	76.325.000	47	82.821.000	51	-	-
	11	302.032.000	186	312.520.000	198	-	-

Unit cost per a kg for concrete poles: 204.060 TL:
Unit cost per a kg for galvanized poles 397.200 TL
1 USD= 1.440.000 TL (2003)

Table 4.7 Pole cost (Source: TEDAŞ)

Pole	Height *meter*	Price *Single Bracket*	Price *Twin Bracket*	Price *Third Bracket*
Concrete				
	7	128.672.500	135.522.800	135.522.800
	8	145.565.200	153.005.500	153.005.500
	9	182.042.000	190.874.500	190.874.500
	10	2.220.105.000	224.100.800	224.100.800
	11	248.327.400	257.357.700	257.357.700
Steel (Globe)				
	1	46.000.000	-	-
	2.35	95.000.000	-	-
	3	40.000.000	45.000.000	45.000.000
	5	-	-	60.000.000
Galvanized				
	5	94.993.400	103.078.200	-
	11	375.911.200	400.165.600	-

Table 4.8 Arm Cost (Source:TEDAŞ,2003)

Type	Price *TL*	Weight *kg*	Total Price *TL*
Single			
1 meter	7.416.000	25	11.251.750
2 meter	13.582.000	50	21.253.500
Twin			
1	10.537.000	45	17.441.350
2	20.252.000	90	34.060.700
Three			
1	13.425.000	65	23.397.950

Unit cost per a kg: 153.430 TL
1 USD= 1.440.000 TL (2003)

Table 4.9 Infrastructure & Control System Cost(Source:TEDAŞ,2003)

Type	Price *TL*	Fitting *TL*	Total Price
4*10 NYY cables	2.400.000	9.954.800	12.354.800
2*1.5 NYM cables	376.000	.24.000	400.000
W Automation (3.3A)	4.400.000	-	4.400.000
Photocell	11.623.000	6.607.000	18.230.000
Control panel	459.160.000	75.700.000	534.860.000
Conductor	44.115.000	3.365.000	47.480.000
Electricity meter			
Mechanics	63.070.000	6.300.000	69.370.000
Electronic	481.150.000	12.600.000	493.750.000

1 USD= 1.440.000 TL (2003)

4.2.3. Measuring Lighting Quality With The Analytical Hierarchy Process

Following the data collection of each site, a subjective evaluation is needed to compare the selected residential areas. The subjective assessment helps to evaluate overall quality of night-time visual environment and to determine what factors are important to visual tasks at night. To achieve the assessment, Analytical Hierarchy Process is used that is a multi-criteria analysis. Alternatives may be generated in the way that best achieves the values. As a result, AHP is that a multi criteria decision problem involves ordering the set of outcomes and identifying the decision alternatives.

Malczewski defines that "Multi-Criteria Analysis (MCA) is a decision-making tool developed for complex problems. Multiple criteria analysis has had many successes, but deals with a very difficult problem area. And also multi criteria analysis is a good method to deal with conflictive feature of urban planning problems that is very often neglected in single criterion based methods for urban policy analysis." (Malczewski 1999, p.64)

Multi criteria analysis is not a method for finding an optimal solution for a given problem. It is rather a methodology supporting a decision-maker in analyzing a problem and in finding and comparing various satisfactory solutions that have different properties.

Multi-criteria analysis has components that is establishing objectives and criteria, estimating relative importance weights and, to some extent, in judging the contribution of each option to each performance criterion.

Criterion is considered a generic term that includes both the concepts of attribute and objective. Multi-criteria analysis may be distinguished: MADM (multi-attribute decision making) and MODM (multi-objective decision making. Both MADM and MODM problems are further categorized into single-decision maker problems and group decision problems. (Malczewski 1999)

- The aim of MADM analysis is to choose the best or the most preferred alternative, to sort out alternatives that seem "good" and/or to rank the alternatives in descending order of preference. There are three additive MADM methods: the simple additive weighting method, value/utility function approaches and the analytic hierarchy process." (Malczewski 1999, p. 16)

- MODM decision rules "define the set of alternatives in terms of a decision model consisting of a set of objective functions and a set of constraints imposed on decision variables." These methods focus on five distinctive approaches: Value/ utility function methods, goal programming, interactive programming, compromise programming and data envelopment analysis. (Malczewski 1999)

Consequently, multi-criteria decision includes the concepts of attribute and objective. There are differences between two concepts. Attributes are the properties of the elements. It is generally related with quality factor. On the other hand, objective is a statement about the desired of the system under consideration. So, attributes are used as both decision variables and decision criteria.

In other words, solving a multi-attribute decision making problem is a selection process, as opposed to a design process. The multi-objective decision making problem is continuous in the sense that the best solution may be found anywhere within the region of feasible solution.

Consequently, this study depends on the multi-attribute decision making because it includes both qualitative and quantitative weighting. Since many problems come into question in the measure of lighting quality, a multi-criteria model, that considers both quantitative and qualitative aspects of the problem with a systematic approach, should be developed. For this purpose, analytical hierarchy model has been preferred because this model considers the opinions of every different social-economical group that gives different weights to different criteria and it is also practical to use.

The following information about AHP is adapted from the study called "Analytic Hierarchy Process in the Practice: A Survey of Applications and Recent Developments", prepared by "V. M. Rao Tummala and Y. W. Wan". This is because this paper clearly explains the AHP method and its phases which are defined in the sections from 4.2.3.1 to 4.2.3.6.

4.2.3.1. Analytical Hierarchy Process

Analytic Hierarchy Process (AHP) is a systematic method for comparing a list of objectives or alternatives. AHP is both a quantitative and qualitative approach. AHP may be a powerful tool for comparing alternative design concepts.

This method, which was developed by Thomas Saaty (1989), has been successfully applied to many cases that required complex decision analyses. It disaggregates a complex multi-purpose problem into a hierarchy, whose levels compromise of certain criteria. AHP has been applied to many types of decision situations by different sectors, such as in forestry, medical science, urban planning, engineering...etc.

4.2.3.2. AHP Principles and Axioms

The AHP methodology is based on three fundamental principles; namely, the **decomposition** or **hierarchic design** principle, the **comparative judgment** principle, and the **synthesis of priorities** or **hierarchic composition** principle. These three principles are supported by four axioms, which are stated as below:

- Axiom 1 (Reciprocal Comparison): The decision maker must be able to make comparisons and state the strength of his preferences. The intensity of these preferences must satisfy the reciprocal condition: If A is x times more preferred than B, then B is 1/x times more preferred than A.
- Axiom 2 (Homogeneity) : The preferences are represented by means of a bounded scale.
- Axiom 3 (Independence) : When expressing preferences, criteria are assumed independent of the properties of the alternatives.
- Axiom 4 (Expectations) : For the purpose of making a decision, the hierarchic structure is assumed to be complete.

The decomposition or hierarchic design principle calls for structuring a complex problem into several hierarchical levels in such a way that the criteria representing the first level has a bearing on the second level and the criteria representing the second level has bearing on the third level, and so on. The last level of the hierarchy represents a set of alternatives that are to be compared with the criteria at the level above as shown in Figure 4.8. The objective is to evaluate the alternatives represented at the bottom level and choose the best one in solving the complex problem. If Axiom 4 is not satisfied, then the decision maker is not using all the relevant criteria and/or all the available alternatives to represent the entire hierarchy associated with a given problem; consequently, the solution process for the problem is not expected to be a complete one.

By using the principle of comparative judgments, we may compare pair wise the criteria or attributes at each level in relative terms as to their importance or contribution with respect to a given criterion that occupies the level immediately above. Axiom 1 specifies a condition for reciprocal comparison where as Axioms 2 and 3 guarantee that the criteria being compared are homogeneous and the weights of the criteria must be independent of the alternatives considered. Homogeneity is essential for comparing similar things, as the decision maker tends to make large errors in comparing widely disparate elements such as comparing a grain of sand with an orange. The homogeneity axiom (Axiom2) assures that the criteria or alternatives should be comparable or homogeneous to make meaningful pair wise comparisons. If the elements being compared do not belong to a homogeneous group, then they need to be arranged in different clusters and compared with elements of the same order of magnitude. Similarly, in making pair wise comparisons between two elements, it is reasonable to assume that if an element A is twice more important than another element B, then B is one-half as important as A. This is governed by Axiom 1.

The synthesis of priorities or hierarchic composition assists the decision maker in finding the global weights to the alternatives at the bottom level of the hierarchy by adding the contributions of all criteria in the levels above. Finding such a set of globalized weights is assured by Axiom 3.

4.2.3.3. Applying AHP Methodology

As mentioned above, the AHP methodology is based on a trade-off concept used to determine the overall relative importance of a set of alternatives associated with a decision problem by normalized weights. This is accomplished by structuring any decision problem into several hierarchies, assigning relative scales in the form of a series of pair wise comparison matrices, and using the available decision support system such as the Expert Choice to determine the normalized weights for pair wise comparison matrices and to evaluate the alternatives represented at the lowest level of the entire hierarchy. Thus, the modeling process involves four phases. These are;

Phase 1 **:** Structuring the problem.
Phase 2 : Measurement and Data Collection.
Phase 3 : Determination of Normalized Weights, and
Phase 4 : Synthesis-Finding Solution to the Problem.

4.2.3.4. Structuring the Problem (Phase I)

The structuring phase consists of decomposing any complex decision problem into a series of hierarchies where each level of hierarchy represents all relevant and manageable criteria or elements. These, in turn, are decomposed into another set of elements corresponding to the next level as shown in Figure 4.8. We need to observe the decomposition or hierarchic design principle and Axiom 4 in structuring any complex problem into different levels of hierarchies with complete set of relevant criteria and/or alternatives. If any one of the relevant criteria and/or the alternatives is not properly identified, then the corresponding hierarchical structure is flawed; consequently, the decision will be flawed.

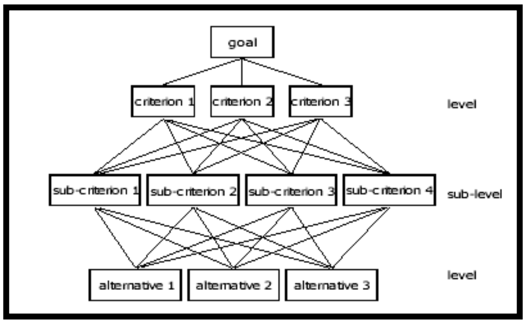

Figure 4.8. Hierarchy in AHP (Saaty, 1989)

Structuring any decision problem hierarchically in this fashion is an effective way of dealing with complexity and of identifying important criteria and/or alternatives to achieve the overall objective of the problem. The AHP allows flexibility in the management decision making process. Furthermore, it allows for the dependence-independence relations among criteria by decomposing them into different levels of hierarchies.

4.2.3.5. Measurement and Data Collection (Phase II)

The second phase of AHP begins with the collection of data and measurement. The judges or evaluators will assign relative scales in a pair wise fashion with respect to criteria of one level of hierarchy given the criterion at the next higher level of hierarchy. This process is continued to all levels of the entire hierarchy. The suggested scaling of weights, called the nine-point scale, is described in Table 4.10. This scaling procedure is governed by Axiom 2.

Table 4.10 The fundamental Saaty's scale for the comparative judgment

Num. Values	Verbal Trems	Explanation
1	Equally important	Two elements have equal importance
3	Moderately more important	Exoerience or judgement slightly favours one element
5	Strongly more important	Experience or judgement strongly favours one element
7	Very strongly more important	Dominance of one element proved in practise
9	Extremely more important	The highest order dominance of one element over another
2,4,6,8	Intermediate values	Compromise is needed.

(Source: Saaty, 1989)

Following this scaling method, the judges will assign relative scales for each pair separately, as to the degree to which one attribute of the pair is important than the other. If objective data is avaible, the judges may use it in assigning scales. Otherwise, they may use their personal beliefs, judgment, and information in assessing scales. Axiom 1 of reciprocal comparison assures that if one criteria A is three times more important than another criteria B, then B is one-third as important as A. Also, Axiom 2 governs the comparability of the criteria or alternatives; that is, all criteria at a given level of the hierarchy must be comparable or homogeneous so that the evaluators may compare them in a meaningful fashion. If they are not homogeneous, then as mentioned earlier, we need to arrange them into different clusters of same order of magnitude to make the pair wise comparison more effective and meaningful. Upon the completion of this process, the pair wise comparison matrices corresponding to each level of hierarchy will be obtained.

4.2.3.6. Determination of Normalized Weights (Phase III)

The third phase of AHP is the determination of normalized weights. The pairwise comparison matrices obtained in phase 2 will now be translated into the largest eigenvalue problems that may be solved to obtain normalized and unique vectors of weights to criteria in each level of hierarchy. Suppose that a given hierarchy levels has n criteria, A1, A2, ….. An with a vector of weights w: (w1, w2, ………, wn). We wish to find w in order to determine the relative importance of A1, A2, …. , An. If the judges assign relative scales by comparing each pair Ai and Aj of these criteria as to the degree by which Ai dominates Aj as wi/wj, and form the pairwise comparison matrix as A, then the normalized vector of weights, w = (w1, w2, ….. , wn) may be found by solving the corresponding largest eigenvalue problem

$$Aw = nw \quad (1)$$

where A is obtained as a nxn matrix of the form ((aij)) = ((wi/wj)), I, j = 1,2, ……, n.

Notice that, by definition (Axiom 1), A is a reciprocal matrix. Furthermore, A is a consistent matrix, since ajk = aik/aij for all I, j, k = 1, 2, …., n. We also know that if the diagonal of A consist of ones (aij = 1) and if A is consistent, then small variations in aij keep the largest eigenvalue to, say λmax, and the remaining eigenvalues close to zero. Thus finding the vector w by solving Eq(1) is equivalent to finding w by solving

$$Aw = \lambda max w \quad (2)$$

In general, in solving Eq (2), we find that w is not a normalized vector. By defining $c=\Sigma\ w_i$ and replacing w by w/c we obtain the normalized vector to determine the relative importance of criteria A1, A2, ……, An.

The consistency index to measure the consistency of the deviation of n from λmax is given by

$$CI(n) = \frac{\lambda_{max} - n}{n-1}$$

Saaty has defined that a decision maker will be perfectly consistent if $\lambda_{max} - n = 0$, so that CI(n) = 0. This notion of consistency is fundamental to the AHP. The greater the departure from consistency, the more randomly chosen is the evaluator's entries in the pair wise comparison matrices. Consequently, the lack of consistency by an evaluator results in less reliable information on which decisions are based. Rather than using this difference to measure the consistency, Saaty developed the concept called the consistency ratio, CR(n) for any pair wise comparison matrix of size n and recommended that $CR(n) < 0.10$ for an evaluator be consistent relative scales.

4.2.3.7. Synthesis-Finding Solution of the Problem (Phase IV)

The last phase of AHP involves the finding of the global or composite normalized weights for alternatives at the bottom level. Since successive levels of hierarchy are related as describe in Figure 4.8, a single composite vector of unique and normalized weights for the entire hierarchy will be determined by multiplying the vectors of weights of the successive levels. Axiom 3 on independence governs this synthesis. This composite vector will then be used to find the relative the problem. As pointed out earlier, AHP has been implemented in Expert Choice to find the composite and unique vector indicating the relative priorities of the alternatives associated with the problem. The system will also provide the consistency ratios, CR (n) for all pair wise comparison matrices.

4.3. Existing physical and amenity structure of selected study areas

This section describes the site analysis and illumination analysis undertaken to understand the general character of the selected areas. It reveals both the quality in a visual, understandable manner and the quantity concerning recommendation standards.

Present patterns of illumination and settlement have been examined to show the functional and visual quality of illumination. Necessary data have been recorded and photographed at both day and night. This intended to help explain installation performances in different sites that are under responsibility of different municipalities.

The sample sites have been chosen to evaluate and measure lighting quality at night. These are:

- Mavişehir - Selçuk blocks,
- Oyak, a parts of 1st and 3rd phase housings,
- Evka 3-municipality blocks.

At the result, the outdoor lighting arrangements are defined different income group approaches for different locations in İzmir.

Figure 4.9 shows that their locations in İzmir. As a result, different illumination approaches in respect to multi family residential areas belonging to different income groups will be defined.

Figure 4.9. Locations of selected residential areas in izmir

4.3.1. Existing physical and amenity structure in Mavişehir

Mavişehir residential area is located in Karşıyaka-Bostanlı. This site is one of the newest districts in İzmir. The construction has taken place in phases since 1993. State treasury is the original landowner. The constructions were realized by Real Estate Bank. This area has high density of population about 17.500. The residential area consists of 3.500 housing units.

Mavişehir residential area is a desirable for high-middle income groups. Generally, people of high-income groups prefer this site due to its quality of life. The major factor for selecting this area is that this site attracts attention in İzmir life in terms of built environment, prestige and social structure.

The first sample site is the first part that is Selçuk blocks in Mavişehir as given in Figure 4.10. It is located the entrance the Mavişehir and is 73646 m^2. It is surrounded with vacant lots on the east side; stream on the west side; Atatürk Anatolia High School at the north side; the main interior road and Mavişehir-Boğaziçi indoor sports complex at the south side.

Figure 4.10 The site plan of Mavişehir residential areas.

It consists of 8 high-rise buildings having different buildings heights (19-16 storey buildings) and 24 two-storey villas. It is composed of 1192 housing unit with two-storey villas. The population of sample area is approximately 4000. The selected area has been established in high quality standards in respect to design layout and elements of streetscape. Mavişehir has facilities that are parking lots, active open areas and local streets like other selected residential areas.

4.3.1.1. Design

The sample site is only a part of 1st phase housings of Mavişehir. The illumination system is under responsibility of the site management. The main and some public minor roads are under responsibility of TEDAŞ as the other selected sides. The site is controlled at 24-hour by the management and technical service personnel. The lighting plan has been provided by technical staff of the site.

There are three points to be considered in discussing existing illumination characteristics:

-**Design Concept**: The illumination system is a simple but a well organized as shown in figure 4.11. The quality of lighting design and selected equipment has been taken into consideration as well as buildings and urban quality. The selection of lighting equipment and these arrangements in Mavişehir have an importance in achieving better illumination rather than the other residential areas.

The illumination pattern is seen uniform; also lighting equipments are integrated well into the environment. A good match of the light to the sample site defines the circulation pattern. The lighting elements in the general area are placed on the corners of landscape areas; building entrances between the back of curb and side walk, so the locations are influenced by property lines and the geometric configuration of the gardens. These are important locations for residents' safety. To sum up, there is systematic approach for pole locations. However, the lighting fixtures could be increased in order to provide an adequate distribution of lighting along the streets and pedestrian ways. This is because that lower mountings require more frequent intervals.

Roadway illumination has a uniform arrangement; besides, these also illuminate parking lots located nearby main and minor roads. On the other hand, parking lots in the district are illuminated by pedestrian-scale lighting and cover wide areas; as a consequence, the existing installations are not sufficient to enhance visual tasks and demand.

The outdoor illumination of Selçuk Blocks has been achieved the quality more successfully than urban residential areas in İzmir and also the other sample areas that are Oyak and Evka 3.

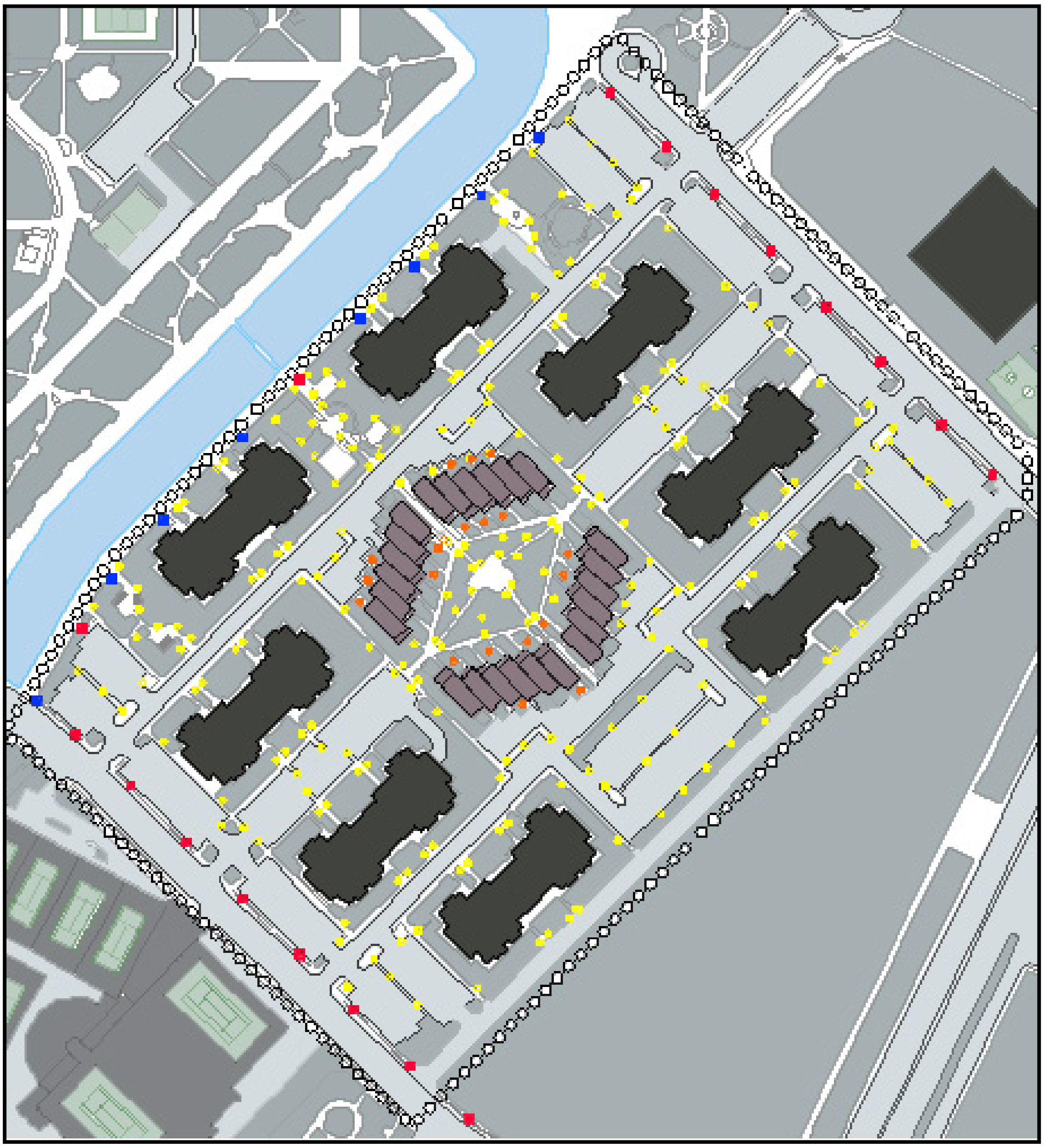

Figure 4.11. The illumination pattern of the sample site in Mavişehir.

- **Equipment characteristics:** The type of equipment has not enough variety for the site; however, there is a hierarchy between the implemented fixtures. There are four types of lighting fixtures used in the sample district (Table 4.11).

In pedestrian areas, parking lots, active open areas and building entrances, a single type is used within in harmony as given in Table 4.11, as Type 1. This type of poles are painted steel are shown as a significant visual element seen both day and night. Moreover, this pole type provides thick profile and relatively expensive rather than the other painted poles; in addition, these require minimum maintenance. Therefore, these are susceptible to defacement by vandals. Their luminaries adopted on the existing utility poles are shielded globes. Shielded fixtures prevent some light from going up, but still are pretty wasteful; on the other hand, the unshielded ones have less of a dark area beneath the globe. The height of their poles is 2.40 meter; and thus they are high enough to illuminate the residential areas.

Figure 4.12. The existing situation in Mavişehir

Figure 4.13. The existing situation in Mavişehir at night

Table 4.11.Equipment characteristics (Mavişehir)

STYLE	FOTO TYPE	ACTIVITY AREAS	LAMP			POLE			LUMINAIRE			ILLUMINATION	
			TYPE	COLOUR	WATT	TYPE	MH	LOCATION	TYPE	BRACKET LENGTH	SPACING	MEASURED LUX	BRIGHT
TYPE 1		Local streets Parks Parking Lots Building Ent.	Ecotone Incandescent	White	40	Aliminium	2.35 meter	Pavement	Globe Unshielded	-	Regular	8 lux	Average
TYPE2		Building Ent.	Ecotone Incandescent	White	40	Aliminium	1 meter	Green areas	Globe Unshielded	-	ırregular	8 lux	Average
TYPE3		Main& Minor Roads	HPS	Yellow	250	Concrete	11 meter	Pavement & Main pedestrian way	250 Watt	1 meter	Regular	20 lux	Average
TYPE4		Main& Minor Roads	HPS	Yellow	250	Concrete	11 meter	Pavement & Main pedestrian way	250 Watt	1 meter	Regular	20 lux	Average

In some residential lots of two storey villas, lower light levels are supplemented using "bollard" lighting that is a small model of luminaire Type 1 as shown in Table 4.11. Bollard lightings are used limited because of their susceptibility to damage and vandalism.

On the other hand, luminaire Type 3 and Type 4, as shown in table 4.11, were installed on main roads and minor roads by TEDAŞ. These are semi-cut off luminaires. Type 3 and Type 4 has seen in similar height; but type 4 has two brackets. The roadway fixtures are located one side of the road. They are situated 30 meter from intervals. These are concrete poles with the latest technology and the mounting height is at 11 meter. If the Type 4 was near the high rise buildings, these would cause light tresspassing because of their height. Type 1 is used in the local streets. Existing illumination system in harmony is comfortable and controlled easily. Beside that, photocells are installed at entrances of multifamily buildings.

Moreover, another important factor is color in respect to diversity of activities. In this site, white color is used for pedestrian applications. In addition, the yellowish colour is used for road lightings. Both of them are suitable for the purposes.

-**Performance**: In the site, there is appropriate and effective light distribution in efficient application because of the uniformity. The globe installations have been measured approximately eight (8) lux by lux-meter. Therefore, in spite of the fact that, these are deprived of standard performance. This is because, the minimum level of illuminance should be proposed as 10 lux. Moreover, the average illuminance levels should be 25 lux in shared use vehicular and pedestrian routes; and also it should be 20 lux in main pedestrian routes. As a result, their illuminance levels of Type1 do not provide visual tasks to be performed at night. The other luminaries located on roads have been measured 20 lux. These illumination levels correspond to the minimum standards recommended.

For the Type 1 luminaires, used lamps are efficient lamps that are 32-Watt ecotone; as a consequence; this is an appropriate standard for residential lighting standards in terms of wattage. On the other hand, these may be upgraded to perform visual tasks. The lamps of Type 4 and Type 3 are 250-Watt High pressure sodium (HPS) have been used 250 Watt luminaires. These are very efficient and relatively long-lived and poor color rendition for roadway illumination and also parking lots.

The uniform lighting arrangement is provided by appropriate electrical controls and ease of maintenance. There is not a problem in term of maintenance. Therefore, the technical service instantly intervenes in problem locations. The performance criterion clearly is supplied. Consequently, the designer is considered by the color of light source, the appearance of luminaries and match of the luminaries to the site.

4.3.2. Existing physical and amenity structure in Oyak

Oyak residential area was founded at 1980's by Turkish Armed Forces Social Organization. The residential areas were built up in phases. The boundary of sample site includes a part of the first and third phase as shown in figure 4.14. The sample site is surrounded by 12-meter-wide minor road on the south side; large green area on the north side, the (army lodgings) on the east side; and the vacant lots and a landmark at the west side.

The area has a varying topography. This site has been designed in the form of terraces including stairs and retaining walls owing to the topography. The hilly slope dominates a big part of the district; therefore, network of transportation, which serves for circulation network, is provided with only 12-meter-wide minor road. This is an important and a single motorized traffic road for people living on the top of the area.

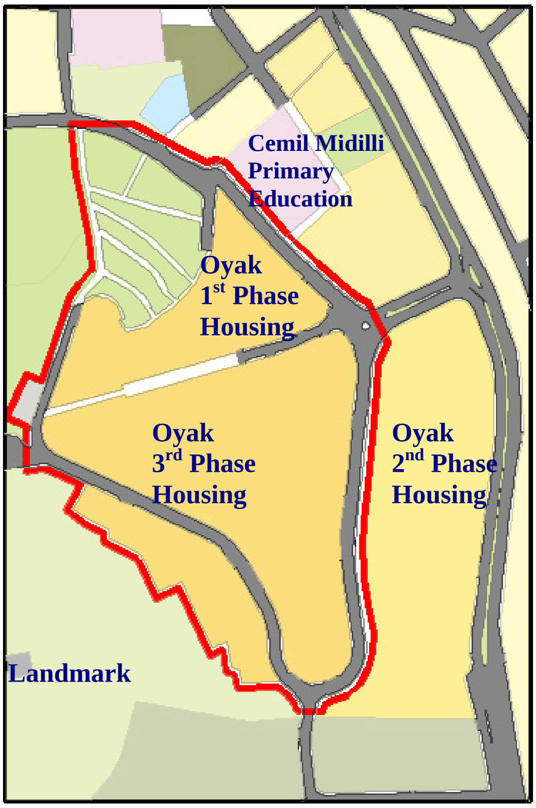

Figure 4.14. The site plan of Oyak residential areas

The parking lots and residential blocks are accessible through this 12 meter-wide-street and stairways that are too long, steep and tiring and has a wealthy natural features. There are two stairs on the area that are the biggest axis. Existing stairs have a great importance for the sample location, because residents generally use the stairways. Therefore, the selected district requires the good illuminated environment at night-time.

The total blocks are 27 containing 483 flats. The sample site consists blocks that are twenty of which are nine storeyed, two of which are seven storeyed and five of which are five storeyed. The whole blocks have 2 housing units at each level. The size of the site is 66375 m^2. The population is approximately 1900. Moreover, the upper middle income groups consist of redundant or active people in the army. In the sample area, there is also a shopping center and big active open areas.

4.3.2.1. Design

Although the sample area has beauty views with wealthy nature landscape by day, it is not seen like daytime by night. This is because the existing illumination does not enhance perceptions of urban form and integrate with effective lighting systems.

Following the on-site observations, main problems determined are as fallows:

- There is still a vast lack awareness of the issues and the common sense solutions.
- The second main problem is apathy; this is because the related institutions do not comprehend how benefits and safe problems about lighting quality are. The urgent interferences are not carried out as well.

- **Design Concept**: Current lighting has a random character among areas, and also it does not provide the original objectives. It is more problematic; therefore, low quality illuminated areas do not satisfy users who are complaint with its problems. To sum up, the existing luminance does not allow comfortable and safe vision and movement in the area.

There is not a uniform illumination in the selected district. The main road illumination is provided by TEDAŞ. The all road lighting fixtures are placed along the one side of the road. Although for roadways there are regularly installed fixtures, the uniform illumination is not provided owing to extinguished lamps. During the night-time observation, the damaged lamps did not change; therefore the resident are mostly complaint about public infrastructure services.

On the other hand, lighting systems in parking lots and pedestrian axis do not include so regularly uniform as the road lights. Therefore, pedestrian areas, parking lots and building entrances located on the steep slope are generally without light or inefficiently lighted. The existing lighting equipments in residential districts do not meet the field and design requirements. During the daytime the pedestrian ways especially, stairs in the area is densely used; but by night, these are not used so densely as daytime. Moreover, the lighting elements installed are not sufficient enough to illuminate the build environment and provide visual and psychological comfort. In addition, the lighting does not be provided by current illumination promoted by the use of pedestrian ways. Thus, the residents refrain from using the stairs after the darkness.

Figure 4.15. The existing illumination pattern of the sample area in Oyak

Moreover, the other problem for the site is the lack of infrastructure system. This is because there is no lighting application in some areas. The residents or managements of blocks by reason of night-time lighting problems improved individual solutions for the surrounding area as given Figure 4.16.

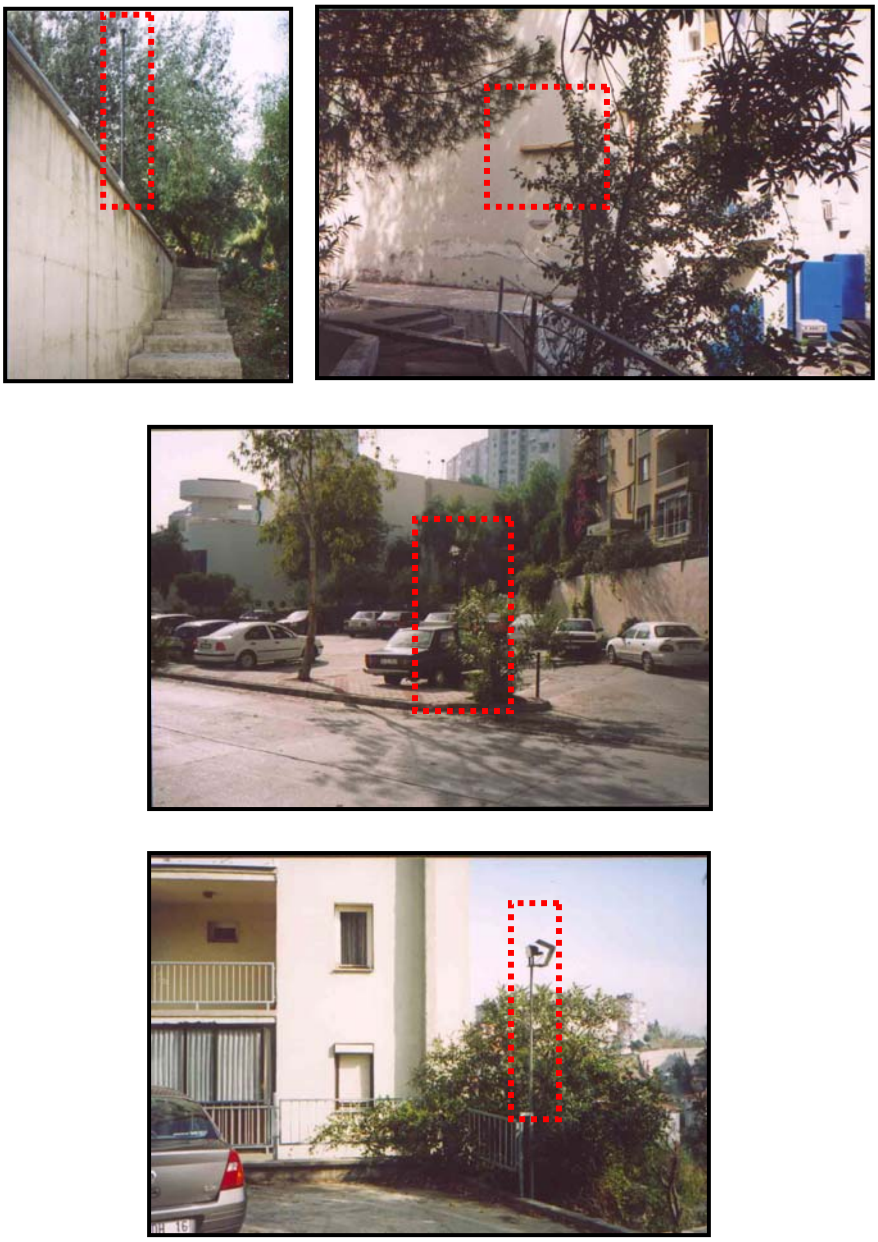

Figure 4.16. The examples from the individual solutions by residents who live in Oyak

Consequently, the sample area have inadequate quality in terms of outdoor space illumination. There is a lack of illumination system in residential location.

Nevertheless, large green park the nearby residential area has illuminated with a lot of globe fixtures.

-Equipment Characteristics: There is a wide variety of lighting fixtures in the sample site. Current arrangements generally do not combine with aesthetical and functional criteria and also do not integrate with field conditions.

The current lighting fixtures are shown in the Table 4.12. In this area the height of the roadway lighting fixtures (type3) is 10 meter. Except for height criterion, the roadway lighting characteristics are the same as the lighting fixtures in Mavişehir. However, their bracket (arm) is at 1 meter. Moreover, Type 4 is located generally at intersections and has three brackets. Type 4 and Type 3 luminaries are semi-cut-off fixtures. The distances between each pole are approximately 40-42 meter. The existing distances between poles cause dark spots in the road and these are affected by existing topography.

Type 1 includes unshielding and shielding globe ones. The globe installations form 73% of the total lighting luminaires in the selected area. The shielded ones prevent some light from going up but still are pretty wasteful. These are mostly non-cut off, resulting again in a lost of light that is lost in the sky. Current pedestrian lighting elements especially type 1 have pole height limits such as 3 meter. Their poles proved trim profile and relatively inexpensive but these are seen as require the maintenance or changing. Lighting fixtures –especially in pedestrian areas and parking lots are generally neglected, burned and got old as given in Figure.4.17

Figure 4.17. The main pedestrian axis

Table 4.12.Equipment characteristics (Oyak)

STYLE	FOTO TYPE	ACTIVITY AREAS	LAMP			POLE			LUMINAIRE			ILLUMINATION	
			TYPE	COLOUR	WATT	TYPE	MH	LOCATION	TYPE	BRACKET LENGTH	SPACING	MEASURED LUX	BRIGHT
TYPE 1		Parks Parking lots & Main Pedestrian ways	Incandescent	Yellow	40	Steel	2.5-3 meter	Green areas Pavement Stairs	Globe unshielded	-	Irregular	10 lux	Poor
TYPE2		Pedestrian way	Incandescent	White	20	Steel	2 meter	on Wall	40 Watt unshielded	-	Single	2-3 lux	Very poor
TYPE3		Main roads & Local Streets	HPS	Yellow	250	Concrete	10 meter	Pavement	250 Watt	2 meter	~26-30 meter ~40-47 meter	15-20 lux	Average
TYPE4		Node & Bus station	HPS	Yellow	250 Watt	Concrete	10 meter	Pavement & Junction	125 Watt	3 * 1 meter	Sinlge	50 lux	Average
TYPE5		Building entrance *security lighting*	Compact fluorescent	White	Twin 11 Watt	-	-	on the wall	2*11 Watt	50 cm	Single	200 lux	Excellent
TYPE6		Entrances *Security Lighting*	fluorescent	White	20Watt	-	60 cm	on the wall	20 Watt	-	Irregular	5 lux	Excellent

Moreover, some electric utilities as cables are connecting the main electric suppliers located over the ground as shown in Figure 4.18. The situation is critique and hazardous for children.

Figure 4.18 The exposed overground cables

Except for the large green areas, in remain sample area; the existing illumination scheme is not enough in respect to number of equipment, fitting quality and illuminance level.

Figure 4.19. The parking lot the have no illumination

Therefore, some lighting fixtures in the area has bought and installed by residents because few years ago, two cars were got fire in Oyak. Some blocks have been improved by the individual solutions as wall lighting, fluorescents, reflectors and globe installations. Florescent lamps are generally installed for illuminate dark areas or transition areas. The use of building mounted fittings should not be preferred in multifamily residential areas; consequently, the fluorescent applications are not appropriate for outdoor illuminance. Besides, fluorescent and incandescent lamps used with globe fixtures may not be used for outdoor applications; because these are more appropriate for indoor applications than outdoor ones. However, recommendations of “metal halide” lamps, which provide better color rendition and have higher energy efficiency rating, are not used here.

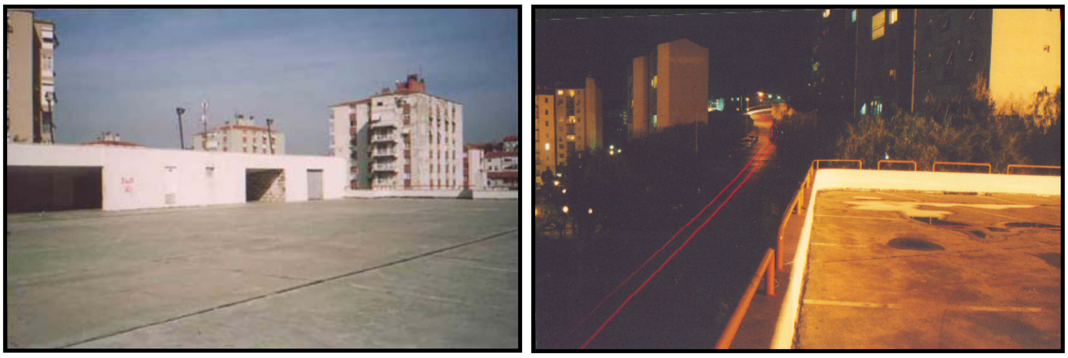

Figure 4.20. The illumination of flood lightings in Oyak

Figure 4.20 shows that the illumination of flood lightings (Type 7) is provided by reflectors installed above the roof of the Migros. The illumination of flood lightings cause the light trespass for resident and discomfort glare for the drivers as shown in Figure 4.20.

- **Performance:** Except for the burned lamps, the roadway lights include two lamp types; these are 125 Watt MV and 250 Watt HPS. Except the burned lamps, the illumination level of 125 Watt MV is 10-12 lux; on the other hand, the illumination level of 250Watt HPS is 20 lux. The results indicate, “250 Watt HPS lamps are more effective than 125 Watt MV lamps.

Moreover the illuminance of globe types (Type 1) is mostly provided by 40 Watt incandescent lamps. These are measured between 10-15 lux. Minimum standard may be supplied; but the average standard is 20 lux. In addition, incandescent lamps are not efficient in terms of illuminance level, average life and color characteristics; and these cause more energy consumption and the dark areas.

Consequently, selected district in Oyak, there is lack of design and lack of installation quality. The site is irregularly illuminated; as a consequence the recent lighting should upgraded.

4.3.3. Existing physical and amenity structure in Evka-3

Evka 3 "settlement is located on the northeastern part of Bornova, in Erzene Quarter, on the eastern side of Manisa motorway, The settlement is far from 13 km the center of İzmir. It is restricted on the west by İzmir-Manisa motorway, on the south by Ege University residential blocks, Keresteciler Industrial Site, on the north by the pines, on the east by projected İzmir-İstanbul expressway.

Evka 3 residential area was organized by the help of Evka-2 Housing Construction Cooperative. The total area is 31 ha. Housing types are the triplex residences and flats including 1408 units in total.

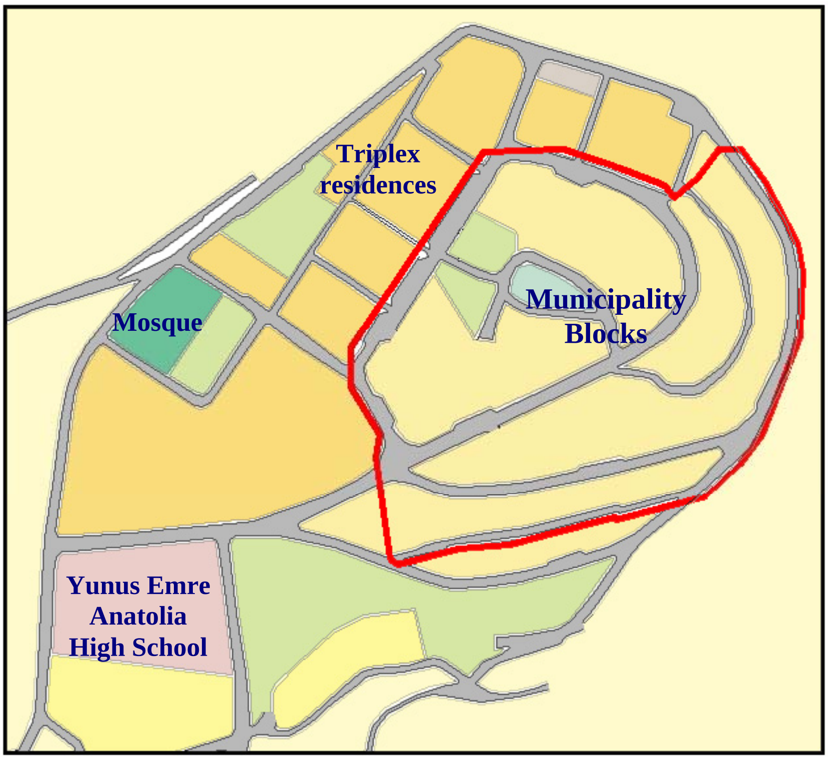

Figure 4.21. The site plan of Evka-3 residential areas

The sample area is limited as given in the Figure 4.21. It is approximately 80 hectares. The area has 49 blocks and includes 338 housing units and 1352 residents. The sample area is surrounded with triplex villas and vacant lots that have rich vegetation. The sample area represents the low-income residents and also includes the blocks (5-6 storey buildings) built up by municipality.

The sample district has variances in terms of topographical structure. The area has a slope between 5% and 30%. Some blocks are located on an undulating area. The undulating area was constructed by terraces and retaining walls; but pedestrian network is not enhanced between the urban terraces. The roadways are also used by pedestrians. Moreover urban terraces are too narrow; and thus only a building was built for each terrace. In addition, the roads between terraces are narrow with a width of 10 meter.

4.3.3.1. Design

The selected sample site is controlled by TEDAŞ; only the active open areas are under the responsibility of Bornova municipality.

Evka-3 night-time street environment without roads may be defined as dark and deserted by reason of bad and insufficient outdoor lighting. For many people living in Evka-3, the bottom line on the site is safety & security.

-**Design Concept:** The current design does not present an attractive, effective concept; therefore it does not utilities possible techniques. Like Oyak, the illumination schemes urgent need to illuminated night-time environment.

The road around the flat area is constructed as staggered arrangement; and other minor roads are illuminated by the single sided lighting equipments. However, the existing trees prevent effective light distribution. Beside that, majority of streetlights around the flat area have overhead street wires with street fixtures attached to the poles due to infrastructure problems. Therefore, the existing views cause streetscape cluster and are critique for people safety.

Figure 4.22. Visual clutter in the roadway

On the other hand, local streets and parking lots appear as darker zones or low quality illumination. Moreover, pedestrian areas and parking lots may be described as inadequate illumination and darkness environments; therefore these do not adequately illuminate not only the space occupied by people, but also the elements within those spaces such as stairs, walls, benches and landscaping. To sum up, the outdoor illumination does not encourage pedestrian activity for especially women. Moreover, the building entrances are so dark that they should be illuminated for both security and functionality.

Figure 4.23. Existing Lighting poles in the scene

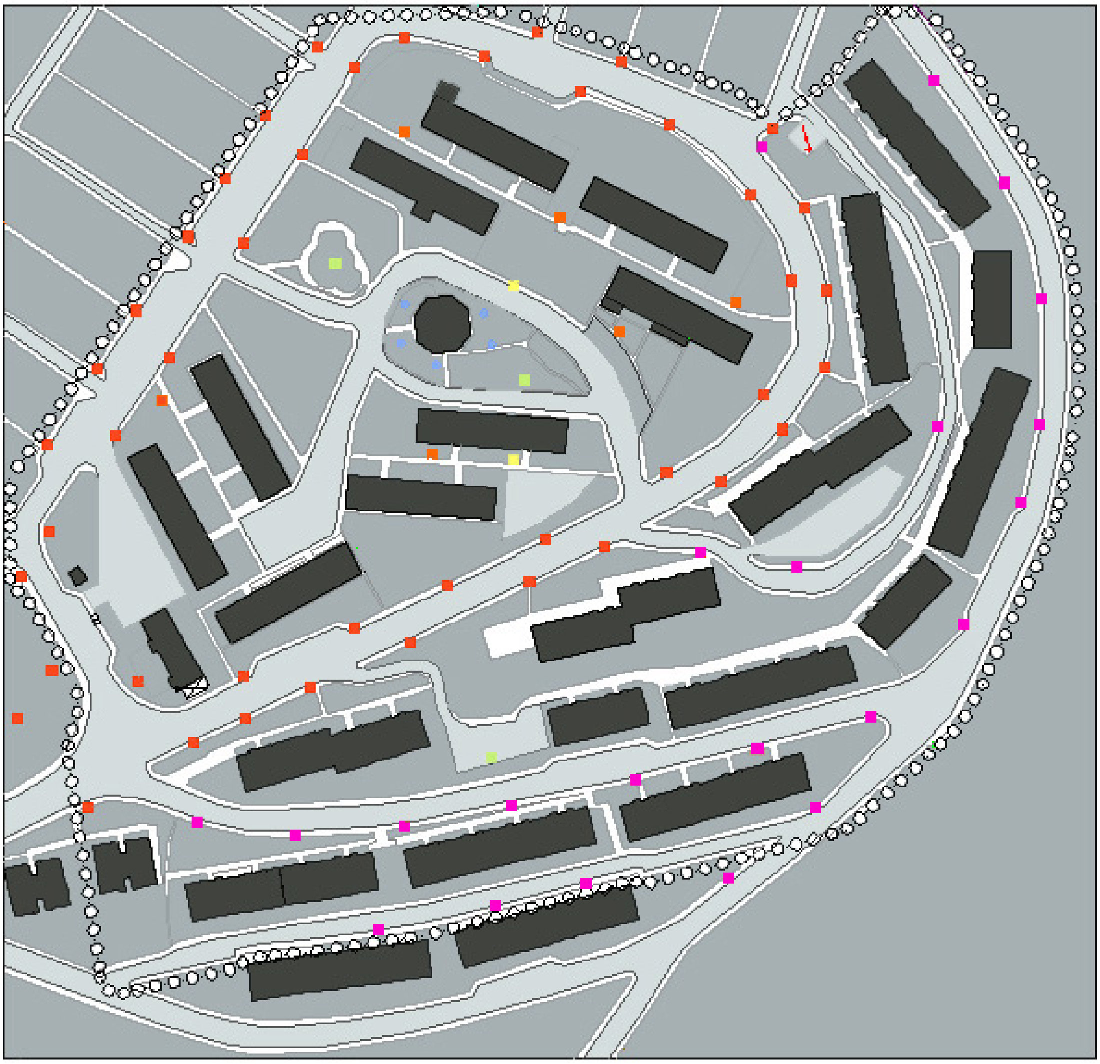

Figure 4.24. The existing illumination pattern of the sample area in Evka-3

- **Equipment Characteristics:** The installed lighting equipments do not completely combine with spaces and the other furnishings and also aesthetic. Type 1-globe types that have two luminaries and unshielded, but these generally have been damaged. Therefore, few ones of globe may illuminate the environment. These lamps are 40 Watt and generally get older; and the height is 3 meter.

As given in Table 4.13, Type 2 is located in the local streets and at the corners of the plots. These poles are galvanized and their lamps are fluorescent similar to Type 3. The single difference is luminaire types. Type 3 is 2*11 Watt compact flurescent; however Type 2 is 20-Watt fluorescent luminaire. The fluorescent lamps especially CFL have several advantages such as longer life and a white light; however, they provide high

Table 4.13.Equipment characteristics (Evka 3)

STYLE	FOTO TYPE	ACTIVITY AREAS	LAMP			POLE			LUMINAIRE			ILLUMINATION	
			TYPE	COLOUR	WATT	TYPE	MH	LOCATION	TYPE	BRACKET LENGTH	SPACING	MEASURED LUX	BRIGHT
TYPE 1		Parks	Incandescent	Yellow	40	Steel	2.40 meter	Green areas	Globe shielded	2 * 0.30cm	Irregular	15 lux	Poor
TYPE 2		Local Streets Building entrances	Fluorescent	White	20	Galvanize	3 meter	Green areas & Undefined areas	20 Watt	60 cm	Irregular	13 lux	Excessive
TYPE 3		Local Streets & on property	Compact Fluorescent	White	Twin 11 Watt	Galvanize	3 meter	Green areas & Undefined areas	2*11 Watt	40 cm	Irregular	20 lux	Average
TYPE 4		Main roads	MV HPS	White Yellow	125Watt 250Watt	Concrete	8 meter	Pavement	125 Watt 250Watt	1 meter	~26-34 meter	12 lux 18-20 lux	Average
TYPE 5		Minor roads	MV HPS	White Yellow	125Watt 250Watt	Concrete	8-meter	Pavement	125 Watt 250Watt	50 cm	~30-42meter	12 lux 18-20 lux	Average
TYPE 6		Parks & parking lot	MV	White	125 Watt	Steel	6 meter	Pavement	125 Watt	3 * 40 cm	Irregular	100 lux	Average (generally damaged)

brightness that are not available for outdoor applications. The existing types with fluorescent lamps -especially Type 2- cause light pollution because their luminaries do not prevent loss of light and do not provide visual comfort. Their luminaries are galvanized that have easily installation properties.

Type 4 and Type 5 have been used on roadways. These are concrete poles and their height is 8 meter. However, Type 5 poles combine directly luminaire; on the contrary, Type 4 luminaire attached to the pole with one-meter arm. Beside that, Type 6 has painted steel with three brackets. One of them located in park is only active. Their poles have been corroded by loosing their physical, chemical and other characteristics affected by the atmospheric conditions. Therefore, these are in low quality.

- **Performance**: The majority of street lights have been installed as both blue and orange yellow spectrum. Existing poles and fixtures are determined as inappropriate poles and fixtures with poor and excessive optical control. Especially fixtures that have globe and fluorescent luminaires are not preferred as good illumination in residential areas and these luminaries are seriously criticized by experts.

Evka 4 currently has a streetlight standard between 10-20 lux respectively 125 Watt MV and 250 Watt HPS. The illuminance of fluorescent luminaires is measured 10lux for globe fixtures; 50 lux for Type 6 luminaires, if they were lighted. The existing luminaires are seriously criticized in the world. Moreover, vandalism is the most problem for the providing quality for public realm in the site. The insufficient numbers of fittings have been broken, damaged etc. Nevertheless, the maintenance services are not regularly performed.

Figure 4.25. The existing fixtures damaged

Consequently, current structure of illumination does not provide any functional and aesthetical illumination for the residents and visitors. Most residents have been complaining about the darkness at night-time activity.

4.3.4 Evaluation

Field survey enables the determination of outdoor lighting principles and their problems. According to the results taken from the field survey involving three different residential areas in İzmir, it may be concluded that much more high-quality life standards at night have been provided in Mavişehir in accordance with lighting composition, choice of lighting element and other technical and functional aspects but except for illumination level. The most important factor for this could be that lighting system in Mavişehir has been arranged and has been controlled by technical staff belonging to this residential area.

In the residential areas of Oyak and Evka3, lighting system is generally insufficient, inadequate with technical aspects, and deprived of aesthetical values, and adequate and orderly maintenance. Lighting system in these residential areas were designed by Tedaş and related Municipalities and maintenance services have been obtained from these institutions. Also Municipalities and TEDAŞ have not been organized. Results of the field survey applied at the residential areas of Oyak and Evka3 show that related public institutions do not give any importance to outdoor lighting included in infrastructure installations. Oyak and Evka 3 residential areas have many design problems. The design problems concerning outdoor lighting could be tackled in two sections:

- The first problem consists of engineering problems because existing installations are deprived of general illumination principles and requirements. In general, the design problems include uncontrolled and inappropriate selection and arrangement of lighting equipments. Improperly installed light fixtures as non-cut off and semi-cut off create the problems of excessive glare, light trespass, sky glow and higher energy use. On the other hand, selection of light fixtures or lamps usually do not provide enough illumination for each activity for instance, the metal halide lamp that is the most proper lamp for installation in residential areas, are not used in three selected areas. Thus, without Mavişehir, outdoor practice has been caused poor lighting schemes and poor visibility, and it does not provide visual and psychological comfort. Furthermore, some areas have been identified as darkness in these areas, especially pedestrian paths at night because of lamps being out of use, and absence of luminaries etc.

- The second problem could be attributed to streetscape arrangement problems that depend on design quality. It may be assumed that a comfort system could be introduced for residential area lighting similar to city lighting. However, the existing lighting systems are not incorporated with the lighting level, uniformity and glare control. Some areas have been built up without lighting plans or are still in darkness. The design problems may be defined as follows:

    -One of the current problems is that outdoor lighting schemes have been applied generally according to roadway concepts but pedestrian lighting is neglected unfortunately. However, the current arrangements of road lighting do not provide adequately uniform lighting distribution. According to functions, current installations do not meet visual needs and demands.

    -The most common visual problem that has existed with outdoor lighting in public outdoor spaces is the lack of composition of an efficient lighting system. Generally in public outdoor spaces, street and pedestrian lighting does not coordinate with other elements of streetscape. The existed lighting design increases clutter as visual problem. Moreover, the scale, style, level of illumination and lamp type has been often applied inconsistently and uncoordinated in design. Determined locations are inappropriate for an effective distribution. Generally the lighting design does not allow little differences between streets of varying functions. The design and installations do not also integrate with site topography.

    - The public system does not serve to define the circulation hierarchy of an installation. Especially on residential streets, the scale of lighting standards and high-level illumination is not often provided. In some areas unshielded luminarie have been used and caused discomforting glare. Furthermore, some pedestrian lighting arrangements or fixtures are incompatible with the adjacent surroundings or highly susceptible to vandalism.

- The last problem is vandalism. In some active open areas and pedestrianized areas, there are rehabilitation or renewal projects on streetscape elements and arrangements. However, the innovations on increased spatial quality have not been avoided to vandalism. In fact, current spatial quality reflects the social duality. In Turkey, for instance, installation of pedestrian-scale lighting equipments has some problems as labour, has been destroyed by user that may not adopt easily.

All the aforementioned problems influence directly both outdoor lighting and so urban quality. Therefore, it may be concluded that high-quality outdoor lighting in residential areas may be achieved by systematical control of the related public institutions. Moreover, economic factors are effective on the quality of outdoor lighting. In Mavişehir, where comfort conditions are high, an outdoor lighting scheme with high cost has been installed. However, outdoor lighting scheme with high cost does not provide high-quality lighting by itself. Lighting at right locations and with appropriate techniques will probably provide economical and high-quality lighting. High quality outdoor lighting will also provide positive effects for the public outdoor space such as ambiance, uniformity, orientation, and comfort. Consequently the field survey is supported by them.

4.4. Cost Analysis

Within the context of analysis of lighting cost, equipment cost, installation cost, and energy and operational costs have been determined in the selected residential areas as shown in Table 4.14- 4.15- 4.16. In sum, the cost data have converted the square m2 costs. Coefficients in terms of cost per unit have been determined for each residential area as shown in Table 4.14.

Table. 4.14. The cost analysis of outdoor lighting installation for Mavişehir

Site Name: Mavişehir

	Luminaire Type1	Luminaire Type2	Luminaire Type3	Luminaire Type4	Total
A- Luminaire Name	Globe	Globe	250 Watt HPS	250 Watt HPS	-
B- Lamp Type	32 W Ecotone	32 W Ecotone	250 Watt HPS	250 Watt HPS	-
C- Number of Luminaires	234	20	8	34	
D-Cost per Luminaire (Table 4.4)	-	-	56.469.000 TL	56.469.000 TL	-
E- Total Luminaire Cost (D*C)			451.752.000 TL	1.919.946.000 TL	2.371.698.000 TL
F- Lamps per Luminaire	1	1	1	1	-
G- Total number of Lamps	234	20	8	34	296
H-Lamp Cost (Table 4.5)	6.000.000 TL	6.000.000 TL	18.323.000 TL	18.323.000 TL	-
I-Total Lamp Cost (G*H)	1.404.000.000 TL	120.000.000 TL	146.584.000 TL	622.982.000 TL	2.293.566.000 TL
J-Number of Poles	234	20	8	17	
K- Pole Cost (Table 4.6)	95.000.000 TL	46.000.000 TL	87.120.000 TL	95.130.000 TL	-
L- Cost per Arm (Table 4.8)	-	-	7.416.000 TL	20.252.000 TL	-
M-Total Pole Cost (J*(K+L))	22.230.000.000 TL	920.000.000 TL	756.288.000 TL	1.961.494.000 TL	25.867.782.000 TL
N- Length of 4*10 NYY					323 meter
O- Total cost of 4*10 NYY					775.200.000 TL
P- Length of 2*1.5 NYM					832 meter
Q-Cost per meter of 2*1.5 NYM (Table 4.9)					332.800.000 TL
R- Cost of W Otomat in the site					1.302.400.000 TL
S-Cost for Photocell					34.869.000 TL
T- Cost for control panel					1.377.480.000 TL
U- Cost for conductor					132.345.000 TL
V- Cost for electricity meter					1.443.450.000 TL

W- Total Equipment Cost					35.940.590.000 TL
X- Labor					8.937.728.000 TL
Y-Total Installation Cost (W+X)					**44.878.318.000 TL**

Annual Cost

A1-Average daily use	11	11	11	11	-
A2- Operating time (365*A1)	-	-	-	-	4015
A3- Lamp Power					-
A4- Energy Use ((G*A3)*A2*1.2)	-	-	-	-	89749 Kwh
A5- Maintenance Cost	-	-	-	-	270.258.055 TL
A6- Electricity cost	-	-	-	-	153.000 TL
AA- Annual Energy Cost(A4*A6)					**13.731.597.000 TL**
BB-Annual Operating Cost (A5+AA)					**14.001.855.000 TL**

Table. 4.15 The cost analysis of outdoor lighting installation for Oyak

Site Name:OYAK

	Luminaire Type1	**Luminaire Type2**	**Luminaire Type3**	**Luminaire Type4**	**Luminaire Type5**	**Luminaire Type6**	**Total**
A- Luminaire Name	Globe	reflactor	250 Watt HPS	125 Watt HPS	2*11 Watt compact f.	20 Watt f.	-
B- Lamp Type	40 Watt incan.		250 Watt HPS	250 HPS	2*11 Watt compact f.	20 Watt f.	-
C- Number of Luminaires	135	5	29	3	1	10	183
D-Cost per Luminaire (Table 4.4)	10.000.000	50.000.000 TL	56.469.000 TL	42.868.000 TL	11.239.000 TL	17.930.000 TL	
E- Total Luminaire Cost (D*C)	1.350.000.000 TL	250.000.000 TL	1.637.601.000 TL	128.604.000 TL	11.239.000 TL	170.930.000 TL	3.548.374.000 TL
F- Lamps per Luminaire	1	1	1	3	2	1	
G- Total number of Lamps	135	5	29	9	2	10	190
H-Lamp Cost (Table 4.5)	270.000 TL	2.000.000 TL	18.323.000 TL	18.323.000 TL	3.272.000 TL	600.000 TL	
I-Total Lamp Cost (G*H)	36.450.000 TL	10.000.000 TL	531.367.000 TL	164.907.000 TL	6.544.000 TL	6.000.000 TL	
J-Number of Poles	135	-	29	3	-	-	
K- Pole Cost (Table 4.6)	40.000.000 TL	-	84.270.000 TL	93.880.000 TL	-	-	
L- Cost per Arm (Table 4.8)			7.416.000 TL	13.425.000 TL			
M-Total Pole Cost (J*(K+L))	5.400.000.000 TL	-	2.658.894.000 TL	321.915.000 TL	-	-	8.380.809.000 TL
N- Length of 4*10 NYY							267 meter
O- Total cost of 4*10 NYY							640.800.000 TL
P- Length of 2*1.5 NYM							751 meter
Q-Cost per meter of 2*1.5 NYM (Table 4.9)							300.400.000 TL
R- Cost of W Otomat in the site							805.200.000 TL
S-Cost per Photocell							34.869.000 TL
T- Cost for control panel							1.377.480.000 TL
U- Cost for conductor							132.345.000 TL
V- Cost for electricity meter							189.210.000 TL
W- Total Equipment Cost							15.987.304.000 TL

X- Labor							11.160.775.100 TL
Y-Total Installation Cost (W+X)							**27.148.079.100 TL**

Annual Cost

A1-Average daily use	11	11	11	11	11	11	-
A2- Operating time (365*A1)	-	-	-	-	-	-	4015
A3- Lamp Power	40 Watt	50 Watt	250 Watt	250 Watt	11 Watt	20 Watt	-
A4- Energy Use ((G*A3)*A2*1.2)	-	-	-	-	-	-	74062 Kwh
A5- Maintenance Cost	-	-	-	-	-	-	878.763.853 TL
A6- Electricity cost	-	-	-	-	-	-	153.000 TL
AA- Annual Energy Cost(A4*A6)							**11.331.486.000 TL**
BB-Annual Operating Cost (A5+AA)							**12.210.249.853 TL**

Table. 4.16. The cost analysis of outdoor lighting installation for Evka-3

Site Name: EVKA-3

	Luminaire Type1	**Luminaire Type2**	**Luminaire Type3**	**Luminaire Type4**	**Luminaire Type5**	**Luminaire Type6**	**Total**
A- Luminaire Name	Globe	20 watt F.	2*11 Compact f.	125W MV&250 W HPS	125W MV&250 W HPS	125 Watt MV	-
B- Lamp Type	40 Watt f.	20 watt f.	2*11 Compact f.	125W MV&250 W HPS	125W MV&250 W HPS	125 Watt MV	-
C- Number of Luminaires	10	6	2	44	22	9	93
D-Cost per Luminaire (Table 4.4)	5.000.000 TL	17.930.000 TL	11.329.000TL.	56469000/22.165.000 TL	56469000/22.165.000 TL	22.165.000 TL	-
E- Total Luminaire Cost (D*C)	50.000.000 TL	107.580.000 TL	22.658.000 TL	2.175.900.000 TL	820.644.000 TL	199.485.000 TL	3.376.267.000 TL
F- Lamps per Luminaire	1	1	2	1	1	1	-
G- Total number of Lamps	10	6	4	44	22	9	95
H-Lamp Cost (Table 4.5)	270.000 TL	600.000 TL	3.272.000 TL	3.874.000/18.323.000 TL	3.874.000/18.323.000 TL	3.874.000 TL	-
I-Total Lamp Cost (G*H)	2.700.000 TL	3.600.000 TL	130.880.000 TL	676.171.000 TL	273.065.000TL	34.866.000 TL	1.121.282.000 TL
J-Number of Poles	5	6	2	44	22	3	82
K- Pole Cost (Table 4.6)	45.000.000 TL	76.325.000 TL	76.325.000 TL	59.860.000 TL	59.860.000 TL	48.000.000 TL	-
L- Cost per Arm (Table 4.8)	-	-	-	11.251.750 TL	-	-	-
M-Total Pole Cost (J*(K+L))	225.000.000 TL	457.950.000 TL	152.650.000 TL	2.633.840.000 TL	1.316.920.000 TL	144.000.000 TL	4.930.360.000 TL
N- Length of 4*10 NYY							270meter
O- Total cost of 4*10 NYY							3.335.796.000 TL
P- Length of 2*1.5 NY							315 meter
Q-Cost per meter of 2*1.5 NYM (Table 4.9)							126.000.000 TL
R- Cost of W Otomat in the site							4.400.000*82
S-Cost per Photocell							36.460.000 TL
T- Cost for control panel							1.069.720.000 TL
U- Cost for conductor							94.960.000 TL
V- Cost for electricity meter							138.740.000 TL
W- Total Equipment Cost							14.590.385.000 TL

X- Labor	25.000.000 TL	189.866.400 TL	3.999.320.000	5.107.693.800 TL	2.469.460.400 TL	274.887.000 TL	12.066.227.600 TL
Y-Total Installation Cost (W+X)							**26.656.612.600 TL**

Annual Cost

A1-Average daily use	11	11	11	11	11	11	-
A2- Operating time (365*A1)	-	-	-	-	-	-	4015
A3- Lamp Power	40 Watt	20 Watt	11Watt	250-125 Watt	250-125 Watt	125 Watt	-
A4- Energy Use ((G*A3)*A2*1.2)	-	-	-	-	-	-	141644 Kwh
A5- Maintenance Cost	-	-	-	-	-	-	335.600.000
A6- Electricity cost	-	-	-	-	-	-	153.000 TL
AA- Annual Energy Cost(A4*A6)							**21.671.532.000 TL**
BB-Annual Operating Cost (A5+AA)							**22.007.285.000 TL**

Table 4.17 Outdoor lighting cost coefficients for the sample areas

	Equipment	Installation cost (Equipment plus labor)	Energy consumption cost	Operational Cost
Mavişehir	0.30	0.426	0.13	0.13
Oyak	0.168	0.286	0.11	0.128
Evka-3	0.057	0.105	0.19	0.192

This table should be divided into two as equipment cost, and energy and operational costs. According to this, Mavişehir residential area has the highest value of 0.426 within the context of installation costs. However, Oyak and Evka 3 have lower values respectively. Installation cost value in Mavişehir is almost two times greater than the others.

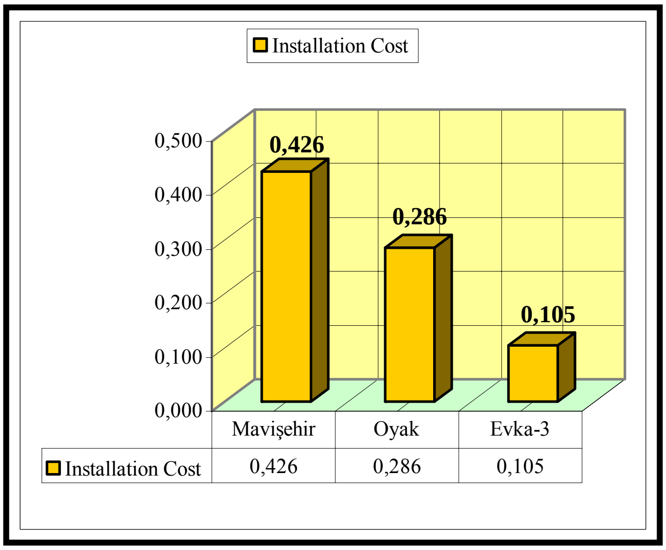

Figure 4.26. Installation cost coefficients

Within the context of installation cost, Mavişehir has the highest value. This is followed by Oyak and Evka 3 respectively. Within the context of economical factors, energy and operating costs are more important than equipment costs. Moreover, Evka 3 has the highest value of operating cost which is composed of energy and operating costs as shown in figure 4.27 and figure 4.28. Due to the fact that Evka 3 has high values of energy and operational costs and maintenance costs but low ratio of equipment coefficient, it may be stated that inadequate and insufficient lighting system will lead to high cost in long term. This is also supported by the analysis results.

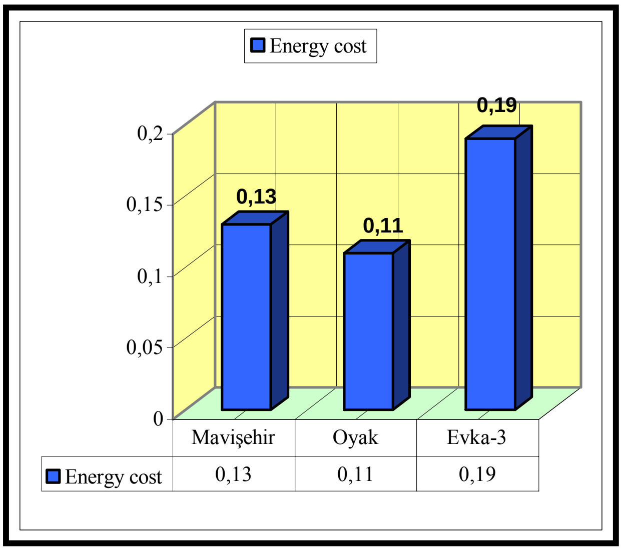

Figure 4.27. Energy cost coefficients

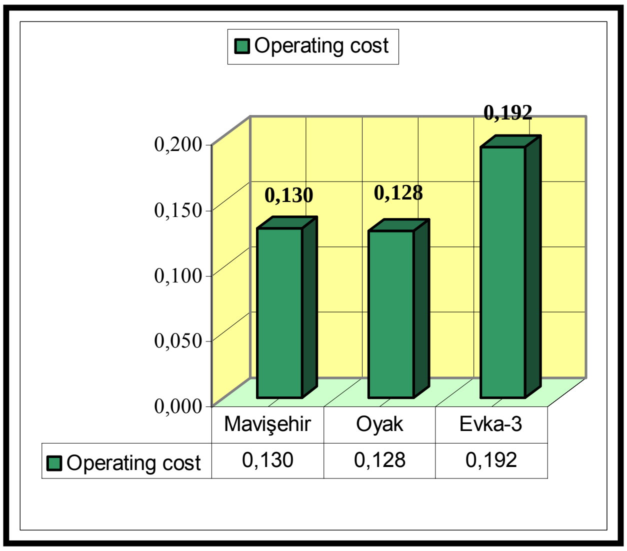

Figure 4.28. Operating cost coefficients

Efficient lighting system which has been formed by optimum equipment cost can easily amortize with low values of operating cost in long term. Therefore, unnecessary energy loss should be prevented within the context of sustainable energy use which has gained importance recently. Unfortunately, in less developed and developing countries equipment costs are generally minimum initially. However, as long as the number of technical staff and public institutions, which may design and install lighting system, increases, sustainable energy use will be provided. Technical staff specialized in lighting has an important factor in achieving high-quality outdoor lighting since lighting system have been designed and installed by technical staff in the residential area of Mavişehir which has the optimum values of energy use.

4.5. Assessment of the Quality of Outdoor lighting System

An Analytical Hierarchy Process model has been used for development of an assessment of the outdoor lighting quality by using residential areas in İzmir. In this process, the selected areas are regarded as alternatives. Quality has been an important factor for outdoor lighting arrangements. Comparison alternatives for outdoor lighting need the development of a method that has several criteria, within the context of a systematical approach. This is because the measurement of outdoor lighting quality requires qualitative and non-quantitative response. Measuring the lighting quality is very difficult, because it consists of multi dimension perspectives, such as visual, perceptual, technical, social and economical. Therefore, AHP, which is a method discussing the problems on the basis of criteria, analyzing them in the form of sub-systems and dealing with different criteria as well, meets these requirements. To sum up, AHP may be used for determining priorities and for measuring the outdoor lighting quality for residential areas.

The aim is to determine an effective and controllable process of increasing lighting quality. Two are the main aims of the evaluation process:

a. definition specifications of the criteria and determine the important criterion.
b. evaluation of the areas and selection of the best one.

In the competitive evaluation of the alternative areas or projects, Analytical Hierarchy Process, which is multi-attribute decision-making tool with a wide range of application area, has been utilized. The modeling process involves four phases. The phases for this study are in the followings.

- **Structuring the problem**

In this process, AHP forms a hierarchy of the goal attributing to alternatives in order to select the best system that maximizes the quality and determine of normalized weight factors for residential areas.

Saaty (2001, p. 23) mentioned that "AHP is used to derive ratio scales from both discrete and continuous paired comparisons in multi level hierarchic structures. The initial hierarchy is the goal, then criteria and alternatives in the final level as given in Figure 4.29.

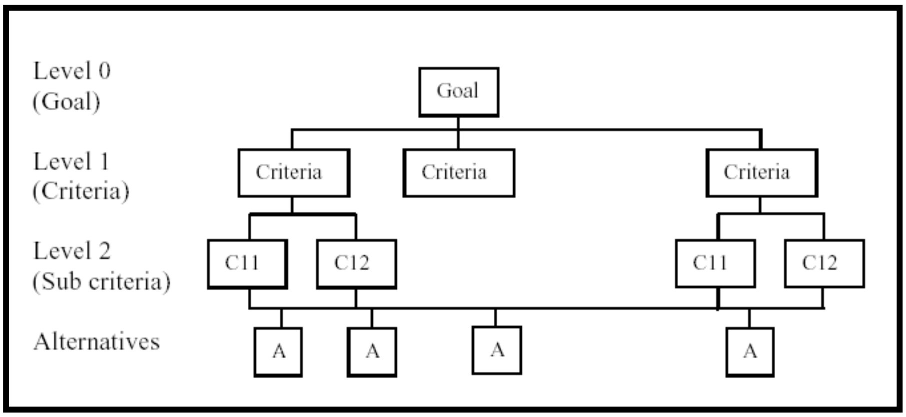

Figure 4.29. Structure Model two level AHP with n factors and m alternatives.
(Source: Saaty 2001)

According to this model, the outdoor lighting schemes in residential areas will be analyzed in four categories; these are:

- Human needs,
- Functionality,
- Economy and
- Facilities.

In the lighting design, human needs, which include safety & security and sense of place, structural composition, technical standards, energy and costs are considered by architects, urban designers and lighting engineers in design process. Parking facilities, circulation facilities and leisure facilities are also vital factors for in residential areas. However, each criterion might not contribute with the same weight for representing the outdoor lighting quality.

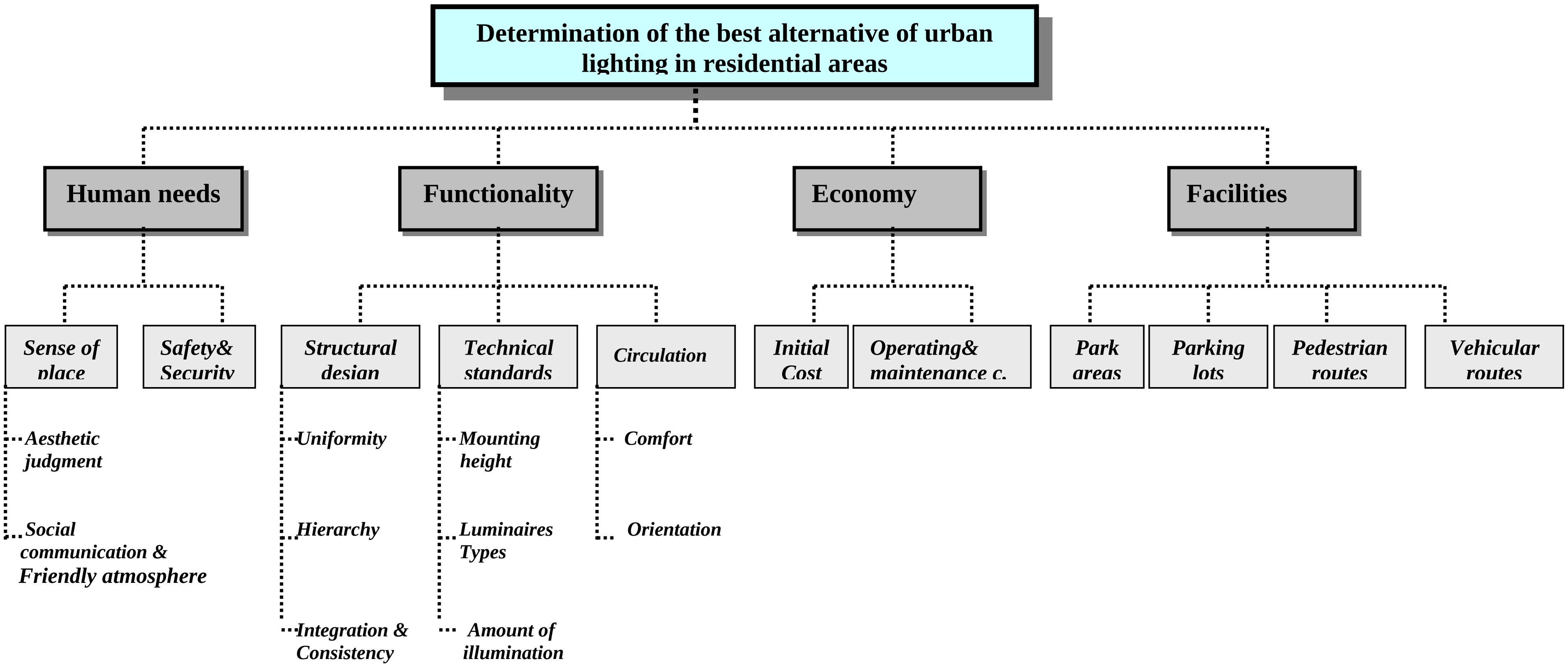

Figure 4.30. AHP model for the outdoor lighting quality of residential areas

AHP model measuring the outdoor lighting quality of residential areas in İzmir could be seen in figure 4.30. The first phase reflects the matrix facts that include human needs, economy, functionality and facilities. The overall goal for the study problem is to determine the best area that maximizes the utilization of the lighting arrangement.

- **Measurement and data collection**

A pair wise comparison adjustment in AHP is utilized for homogenous elements. Table 4.18 shows the fundamental scale for calculating weight in comparative adjustment process.

Table 4.18. Fundamental scale

Intensity of importance	**Definition**
1	Equal importance
2	Weak
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong or demonstrated importance
8	Very, very strong
9	Extreme importance

(Source: Saaty, 2001, p.26)

The usage of above scales in each step is shown in Table 4.18. Each paired criteria is tested 17 options. The numerical values are also used directly.

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Figure 4.31. Pairwise Comparision model (Source, Expert Choice)

Indices are structured by theoretical framework for assessing the outdoor lighting quality. The combination of determined factors / criteria have been used for setting a questionnaire. The questionnaires are distributed to both residents and local professionals. The questionnaire prepared for the residents containing 11 questions and a second questionnaire prepared for the local professional containing 10 questions. (Appendix C) For the residents in sample areas, the standard sampling has been carried out. The number of local professionals related with sample sites has not exceeded 5.

Nevertheless, the results of same sub-criteria have relative scores. Hence, the arithmetic mean is used for determination of the average score for the one criteria; for instance, safety and security has three sub-criteria that include security, pedestrian safety and fear of crime. These have the relative scores. The arithmetic mean is used for the safety & security for a meaningful assessment of the criteria. (Appendix D)

An additional questionnaire is needed to determine the factor score (raw score). The questionnaire is multiple choices for 0 to 3. The explanation of raw score is shown in the Table 4.19.

Table 4.19. Factor score of quality factors

Score	**Definition**	**Explanation**
0	None	Not applicable
1	Poor	Below average
2	Average	Average
3	Excellent	Above average

On the other hand, some residents unconsciously answered the questionnaires and some local professional answers do not clearly reflect the existing situations. On the other hand, these have not been eliminated in this evaluation. Therefore, these affect the ratio of inconsistency.

- **Determination of Normalized Weights**

The calculations required are quite complex. In practice, these would be undertaken by a special AHP computer package. Therefore, Expert Choice software has been used to determine the priorities and arrive at the judgments that have been entered for the criteria with respect the goal and for the alternatives. “The Expert Choice represents a significant contribution to the decision making process. It is based on the analytical Hierarchy Process. It also determines if the comparisons are logical and consistent and if not assists the user to improve consistency through its inconsistency measure". (Expert Choice, 1986 p. 1)

Total weighted value for Mavişehir is *0.530*; Oyak is *0.212* and Evka 3 is *0.258.* The overall consistency is 0.01. (App. E) The best overall inconsistency must not be more than 0,1 to achieve the best evaluation. If the result is more than 0.1, the comparison and evaluation fails. Overall ranking for factors in lighting quality are listed below:

- Human needs: 0,427
- Functionality: 0,365
- Economy: 0.108
- Facilities: 0.099

Table 4.20. The weight factors for each criterion calculated by Expert Choice Software

Level 1		***Level 2***		***Level 3***	
Category/ Goal	***Ranking***	***Factors***	***Ranking***	***Sub Factor***	***Ranking***
1.*Human Needs*	0,427	*Safety & Security*	0,882		
		Sense of place	0,118	*Aesthetic judgment*	0,667
				Social communication & friendly atmosphere	0,333
2. *Functionality*	0,365	*Structural design (Composition)*	0,3	*Uniformity*	0,571
				Hierarchy	0,143
				Integration & Consistency	0,286
		Technical standards	0,6	*Mounting Height*	0,6
				Luminaire types (Cut off.)	0,23
				Amount of illumination	0,648
		Circulation	0,1	*Comfort*	0,8
				Orientation	0,2
3. *Economy*	0,108	*Initial Costs*	0,8		
		Operating and Maintenance Cost	0,2		
4. *Facilities*	0,099	*Park areas*	0,09		
		Parking lots	0,113		
		Pedestrian paths	0,308		
		Vehicular Routes	0,49		

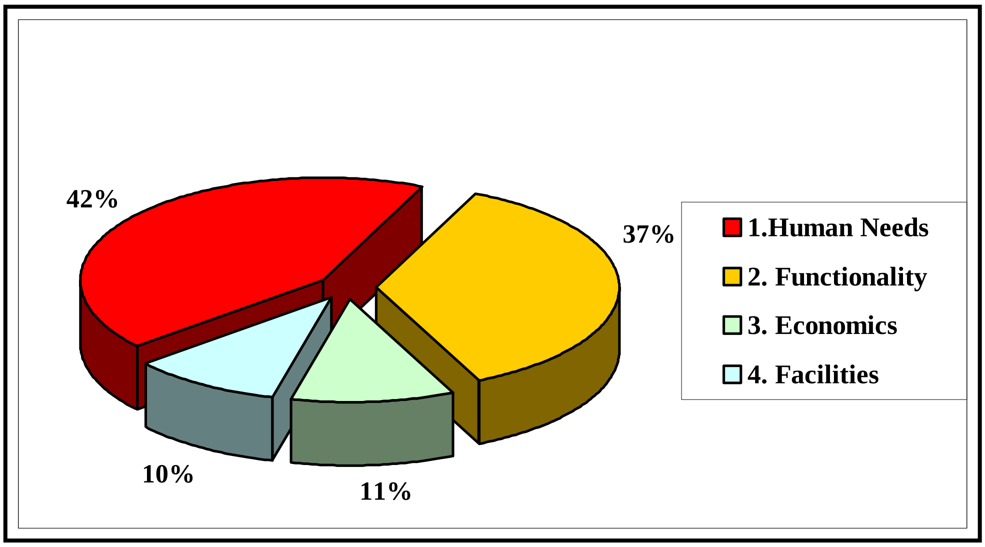

Figure 4.32. The factors that affect the illumination quality

The important factor is human needs, especially for safety and security for residents as you seen Figure 4.32. Safety and security that is weighted 0.882 is more important than sense of place that is weighted 0.018.

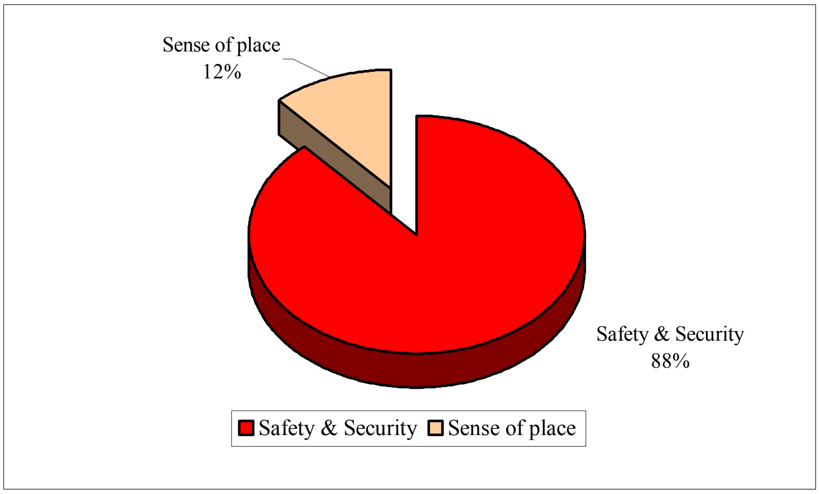

Figure 4.33. The ratio of human needs criteria

The results of scores are determined that the Oyak residential area has low values of safety&security criteria. Another interesting result is that aesthetic judgment is more important in Mavişehir than in Evka 3 and Oyak. For these areas, the other criteria take place first class rather than aesthetic judgment.

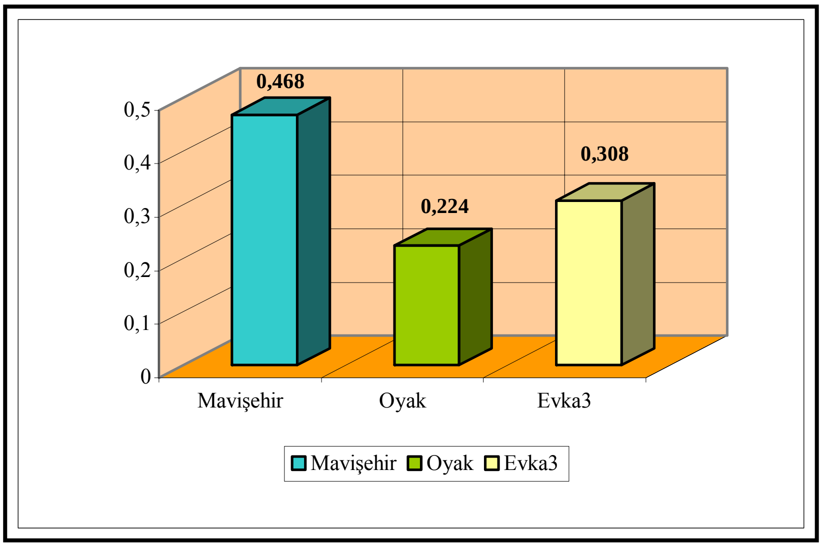

Figure 4.34. Synthesis for respect to human needs

Functionality is the second important category. The most successful residential area for this category is Mavişehir. Besides that, Evka 3 is more successful than Oyak residential areas.

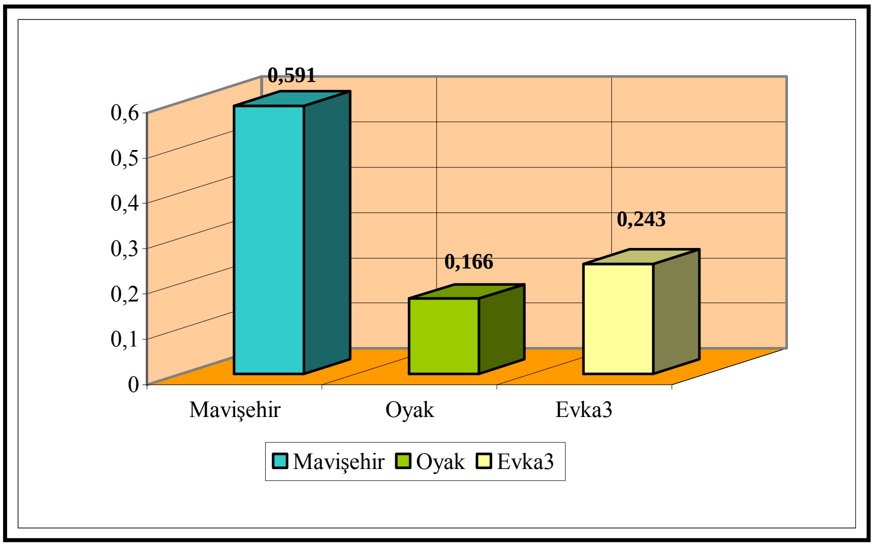

Figure 4.35. Synthesis for respect to functionality

The factor of "Economy" is obtained by application of the cost coefficients for each area as numerical data. The factor is more important than facilities; but is less than functionality and human needs. In the comparison of areas, Mavişehir have more investment than Oyak and Evka3. On the other hand Oyak have more investment than Evka3 inspite of the results of human needs, functionality and facilities.

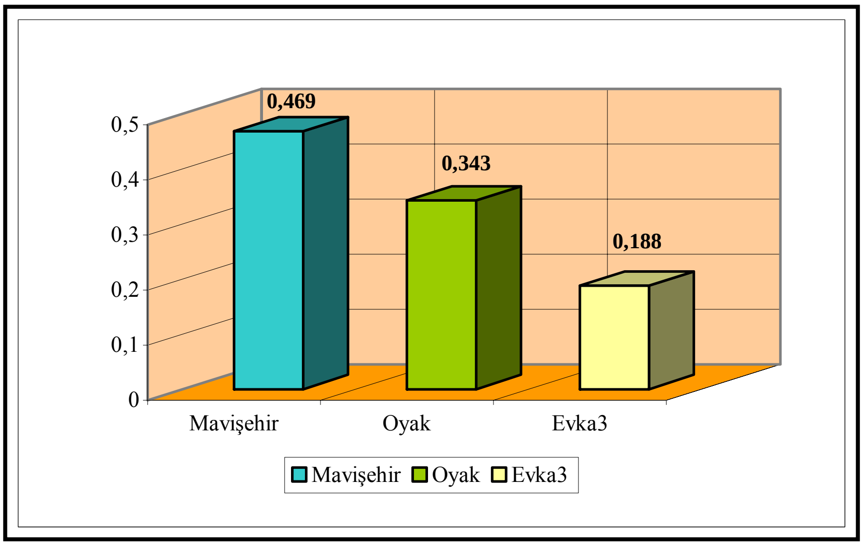

Figure 4.36. Synthesis for respect to economy

The last factor is the facilities. It is the least important category and parking illumination has the lowest value in this category. The important criteria are respectively vehicular routes, pedestrian ways, parking lots and active open areas.

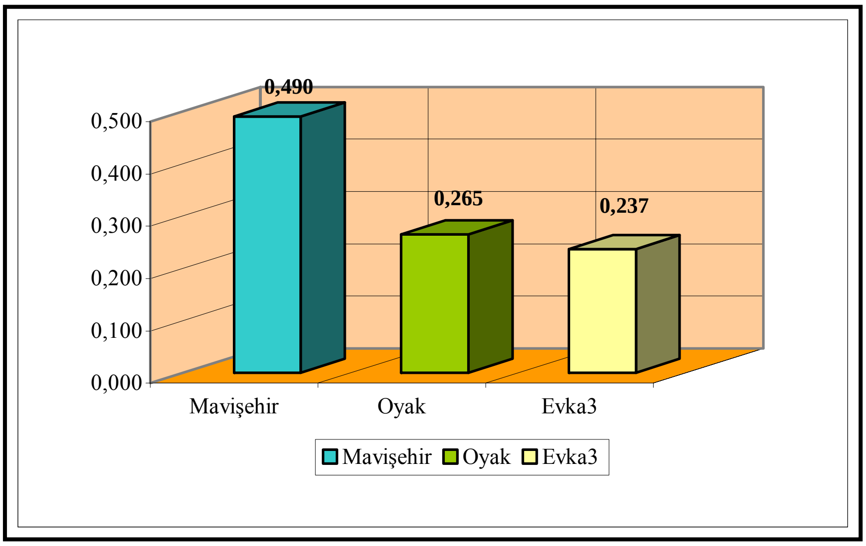

Figure 4.37. Synthesis for respect to facilities

Likewise the other results, Mavişehir illumination for facilities is more successful than Evka3 and Oyak. Except the pedestrian paths, Oyak is more successful than Evka3 because the pedestrian paths have not been illuminated adequately because of the topographical structure that does not allow the residents to use these paths in safety. This may be based on that pedestrian is more defined than Evka3. The residents prefer the illumination of the vehicular roads, pedestrian ways and parking lots much more than the illumination of active open areas.

The weight factors for all levels and alternatives are listed in Appendix C. Consequently, Mavişehir has better quality compare to Evka3 and Oyak. Nevertheless Evka 3, which live low-income groups, have better illumination than Oyak who live middle-income groups. The weight factors that are calculated with AHP are 53% for Mavişehir, 21.2 % for Oyak and 25,8 for Evka3.

4.5.1. Evaluation

This section has tried to compare the quality of night-time illuminated environment of the selected residential areas. It also presents how different factors can directly contribute to the design quality of the project and describe an effective design. Proposed hierarchy approach consists of four indices. According to these indices, this phase may be stated that as;

- **Human Needs**

Human as the resident is the most important factor in residential areas. The residential areas are designed and constructed according to the requirements and expectations of the residents who expect comfort conditions that may meet their visual, functional and psychological needs. Therefore, it is significantly required to awake a lighting system design is based on human needs. Apart from this, outdoor lighting in the night-time environment should meet the most important factors of safety and security rather than aesthetical values.

- **Functionality**

According to the results derived from sub-headings of structural design criteria under the heading of functionality, uniformity is 0.500, hierarchy is 0.143 and integration corresponds to 0.200. Apart from hierarchy and integration criteria, installation of a uniform lighting system has priority. Criterion of “amount of illumination”, which has the highest value under the heading of technical standards, is considered much more than the other criteria. In fact, all these criteria should be important equally in a uniform approach. However, only one criterion is taken into consideration. This shows that the system focuses only on that criterion. As a result, it may be stated that the system may not provide an effective functionality. Moreover, it may be said that considerations of technical staff and their inadequate knowledge may be an important factor leading to problems in the existing systems.

When the factors influencing the lighting quality in the residential areas are compared, Mavişehir is the one that may meet the requirements of the outdoor lighting almost entirely. This is followed by Evka 3 and Oyak respectively. This also shows that it is much more difficult to provide an efficient and a uniform lighting system in a site of hilly slope and it is required to analyze the site prior to design and installation phases. Apart from this, results of this section depend on the results of interviews applied on the residents of the selected residential areas. However, some results do not reflect the real situation of the sites. For instance, residents living in Evka 3 gave positive results although the lighting system is inadequate. Such inconsistent answers, which affected the results even less, have been used in the evaluation. Nevertheless, it may be said that most results are objective. According to the results, residential area of Oyak is the most inadequate area which has very dark plots at night.

- **Economy**

Results related with economy reveal that Oyak has the highest ratios of installation and operating cost in spite of its inefficiency in some cases. However, this is an inconsistency. This result verifies the existing two points determined in the field survey. The first is that the existing system is not active completely, and the second is the illumination of the large park in the area. Thus, high cost depends on the usage of much more lighting equipments and electricity in this large park. Moreover, results influence the other factors since surroundings of the residential areas is also inadequate in terms of lighting. The reason why these two points are high can be verified through the results of field survey.

- **Facilities**

In Turkey, it may be said that roadway lighting has priority and is at optimum illumination levels when compared with the other outdoor spaces as shown in Figure 4.38. This is supported by the results of the analyses. Lighting of the public outdoor spaces except for the roads do not have uniformity as the roads have. Moreover, low level lighting in the active open areas shows that these social activity areas are not illuminated adequately and correctly at night. Accordingly, these areas are generally not to be used effectively at night.

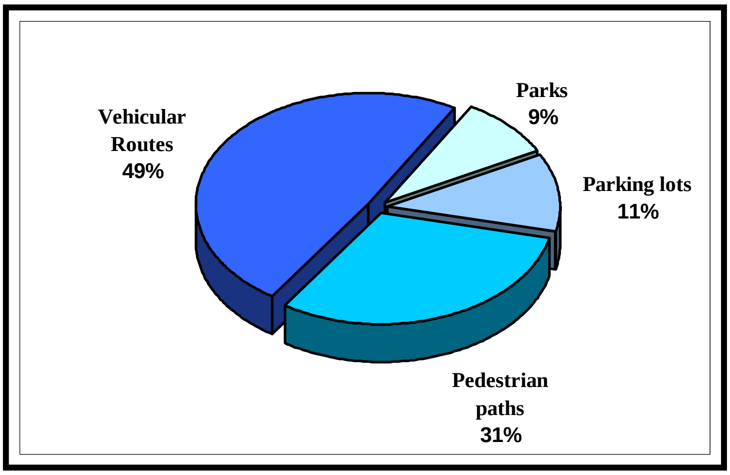

Figure 4.38. Priorities with respect to facilities

Interesting result of the study is that Evka 3 has the second place even though this residential area has an inefficient lighting system and its residents are not aware of adequate and efficient lighting. However, Oyak has the last place although its residents are aware of the lighting problems in that residential area. On the other hand, Mavişehir is at the first place with its lighting system and lighting quality.

CHAPTER 5

CONCLUSION

Outdoor space lighting may be regarded as one of the most important factors of contemporary urbanization. Nowadays, cities and towns are aware of the outdoor lighting benefits. Effective lighting design and installations are very crucial to create urban quality at night-time for developing and developed countries. Good lighting contributes to the quality of urban life. Quality is a common concept for outdoor illumination as well as urban life.

With the aim to analyze quality of outdoor space lighting arrangements, which should be improved toward carrying out with a coordinated system being attractive, functional and energy efficient, this study concentrates on the lighting installations of residential areas. Furthermore, it has also tried to put forward a comparative approach to assess the quality of outdoor lighting systems in the selected multi-family residential areas including Mavişehir, Oyak and Evka 3. This study presents a critical and analytical look on the outdoor lighting quality in residential areas. An assessment of outdoor lighting quality of the selected residential areas has been carried out in three phases which are field surveys, cost analysis and Analytical Hierarchy Process. Depending on the three-fold research, the findings of the study are presented as follows:

- **Field Surveys and Interviews**

Through design guidelines, the existing lighting installations have been examined and then these illuminance levels have been measured by lux-meter; and finally the current problems of outdoor space lighting have been described especially at night. For this study, the nighttime assessment is important for this study to determine whether the lighting system performance is sufficient, over-designed or under-designed. The results of field surveys proved that the outdoor space lighting of residential areas generally does not include the suitable characteristics considering design, illuminance level, uniformity and visual demands. The field surveys present existing problematic applications that have caused poor quality of public outdoor spaces and dark areas at night-time environment. Existing lighting applications in residential areas assist in quality problems as streetscape and infrastructure design elements.

Interviews with the residents of the selected residential areas have helped to determine whether the lighting on the site is adequate or not. The interviews reveal those approaches as follows:

- ✓ Outdoor lighting approaches differ according to income groups. However, for the three residential areas, general view about outdoor lighting is that "good outdoor lighting provides safety and security". This is because of the fact that the residential public areas can be achieved by installing brighter or additional lights at night-time according to many people. On the contrary, few people mention that "safety and security problems are not resulted from outdoor lighting problems; these are in fact social problems."

- ✓ The legibility of the scene is an important criterion recently introduced in urban planning. Therefore, a balance in brightness and uniformity is an effective criterion to create a degree of legibility within the complex area. However, interviews indicate that lighting in residential areas, especially Oyak and Evka 3, is perceived as deficient by the residents.

Depending on the interviews and field surveys, the research phase of this study has also indicated that unauthorized development is quite often a problem, this is mainly due to genuine lack of awareness of outdoor space lighting principles and planning requirements for outdoor lighting installations. It may be suggested that lack of knowledge and performance problems of the public institutions and their staff is the major factor, in providing outdoor lighting quality in the residential areas. The problems affect directly outdoor lighting as well as urban quality. Therefore, it may be concluded that high-quality outdoor lighting in residential areas may be achieved by systematical control of the related public institutions. Moreover, economic factors are effective on the quality of outdoor lighting. In Mavişehir, where comfort conditions are high, an outdoor lighting scheme with high cost has been installed. However, outdoor lighting scheme with high cost does not provide high-quality lighting by itself. Lighting at right locations and with appropriate techniques may probably provide economical and high-quality lighting. In Oyak and Evka 3 residential areas, lighting system was designed by TEDAŞ and related Municipalities and maintenance services were also obtained from these institutions. Some existing problems are attributed to the fact that these two institutions are not in cooperation. Furthermore, these ideas on lighting equipment are regarded as only technical elements. Besides, other important factor is the mentality of local authorities. Some current installations are directed by expectations of administrators without any specialist related with lighting.

In addition, another important factor is the lack of the ordinance and regulations of outdoor lighting in Turkey. There is a draft about outdoor lighting which was prepared by Minister of Energy and Natural Resources, but it is not validating. Moreover, majority of lighting professionals are not aware of the existence of such a draft. This situation shows the need of both technological improvements for residential lighting and practical usage design guidelines for applying this improved technology through high quality design.

- **Cost Analysis**

After evaluation of the field surveys, cost analyses of selected lighting systems of residential areas indicated that efficient lighting system formed by installation cost could amortize itself in the long term with low operating values. In Mavişehir, while installation cost is high, it shows a low operating cost. Therefore, it should not be forgotten that investments, which are inadequate and lack of quality due to economical restrictions, may lead to much higher costs in the future. The competent of urban areas are also deprived from effective or proper lighting quality, which is mostly attributed to economic restrictions. There is no effective strategy, detailed calculations and awareness of the benefits. Beside that, technical staff specialized in lighting has an important factor in achieving high-quality outdoor lighting since lighting system has been designed and installed by the technical staff in Mavişehir which has the optimum values of energy use.

- **The assessment of outdoor lighting quality with the Analytical Hierarchy Process**

Outdoor lighting system is a specialized system which has a role of providing urban quality and order for more disciplines. This study has developed an evaluation framework for the comparative analysis of outdoor lighting arrangements in the selected residential areas including Mavişehir, Oyak and Evka 3. After the determination of the problems, a hierarchy model has been described for determining a better alternative to measure outdoor lighting quality by identifying the factors in urban design and clarifying the relationships between these factors.

Research on "hierarchy" approach presents how different factors can directly contribute to the design quality of the project and describe the efficient design. In evaluations of quality in residential areas, four indices (human needs, functionality, economics and facilities) have been proposed to compare as a specific design goal and strategy. In addition, the meaning of design quality has been discussed depending on the proposed indices. However, this evaluation reflects not only subjective criteria but also mathematical calculations of initial costs, operational costs and questionnaires results. (Appendix D)

The findings are presented in the section 4.5 beginning on page 143. As shown in Table 5.1; when the factors influencing the lighting quality in the residential areas are compared, Mavişehir is the one which may meet the requirements of the outdoor lighting almost entirely. This is followed by Evka 3 and Oyak respectively.

Table 5.1. Synthesis of the criteria to evaluate the illumination quality of residential areas

	Mavişehir	***Oyak***	***Evka 3***
Safety &Security	4	2	3
Sense of Place			
Aesthetic Judgment	8	0	0
Social Communication	5	2	2
Human Needs	5	2	3
Structural Design			
Uniformity	6	0	2
Hierarchy	3	2	4
Integration	6	2	1
Technical Standards			
Mounting Height	4	2	2
Luminaires Types	5	1	3
Amount of Illumination	6	1	2
Circulation			
Comfort	4	2	2
Orientation	5	1	2
Functionality	5	1	2
Initial Cost	5	3	1
Operating & Maintenance Cost	3	3	3
Economy	4	3	1
Park Areas	5	3	1
Parking Lots	6	2	1
Pedestrian Routes	5	2	2
Vehicular Routes	4	2	2
Facilities	4	2	2
Total	**5: 0.530**	**2: 0.212**	**2: 0.258**

9: 0.9-1	**8: 0.8-0.9**	**7: 0.7-0.8**	**6: 0.6-0.7**
5: 0.5-0.6	**4: 0.4-0.5**	**3: 0.3-0.4**	**2: 0.2-0.3**
	1: 0.1-0.2	**0: 0.0-0.1**	

Depending on evaluation of the illumination based on arrangement in selected areas; human needs have been determined as the most important factor in residential areas. In fact, the factors of human and space are the principal inputs concerning the illumination as well as quality of life. Besides, in comparison with other residential areas, Mavişehir is determined to have a more effective illumination rather than the other residential areas in terms of the factors and sub criteria. The technical staff of Mavişehir residential area control the illumination systems of the site. However, other areas are under responsibility of municipalities and TEDAŞ. Interesting result of the study is that Evka 3 has the second place even though this residential area has an inefficient lighting system and its residents are not aware of adequate and efficient lighting. However, Oyak has the last place although its residents are aware of the lighting problems in that residential area. On the other hand, Mavişehir is at the first place with its lighting system and lighting quality. This is also supported by the results of the analysis.

Eventually, this research points out that the quality of lighting design should be carried out with the appropriate design and regular care and maintenance efforts. The results of the study indicate that the quality problems of outdoor illumination could be decreased with effective design and regular care efforts as seen in the Mavişehir case. The result presenting lighting quality values of residential areas supports the statement of the study. Another outcome is that the cost is not more important than human needs. Arriving at a conclusion in outdoor lighting installations need serious attentiveness and attention as the outdoor illumination issue is very complicated.

Moreover, lighting design should always facilitate in parallel with careful urban design, planning and landscape design since lighting proposals may be influenced by the planning system. A legislative framework is needed which allows lighting issues to be considered with a comprehensive basis. In conclusion, in Turkey, primarily technical people working in public institutions related with lighting should build awareness of the value of good lighting and need for quality lighting for all installations. Outdoor lighting should be controlled by ordinances and new technologies should also be promoted into the new or redesign projects. Furthermore, the proposed lighting systems should be inspected by the experts who may control the designs and applications in the whole city. In addition, both direct and indirect benefits of outdoor lighting installation may be integrated to municipal and public officials.

In Turkey, outdoor lighting schemes should be reviewed and updated or redesigned within the context of lighting specifications and standards. In many cases, especially in residential areas, current lighting equipments have been placed on inappropriate spaced poles with fixtures having poor optical controls. In conclusion, minimizing these problems in residential areas will be provided in case all the criteria are evaluated within the context of general design approaches prior to the application process, and subsequently such a study is performed. It is important to create an urban environment in which all people interested in the residential areas could work together on common goals such as safety, environmental protection aesthetics, quality of life and greater evening activity to improve the life standards in neighborhoods.

Suggested further studies concerning the outdoor lighting may in the future also focus on the following subjects:

- Link between the alternative energy and outdoor illumination by using decision making analysis,
- Outdoor lighting evaluation by a cost/ benefit analysis,
- The formulation of alternative outdoor lighting regulations,
- Development of a lighting master plan to examine urban values.

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APPENDIX A

Lighting Design Terminology

Outdoor lighting includes technical standards and parameter. Therefore, the terminology is prepared in order to understand the information in the following sections. This terminology is adapted from “ Urban Design Manual”, including Section Lighting

1. Light Terms and Units:

The following are the important terms currently in use to describe the physical properties of light and corresponding units of measurement.

- **Lumen (lm):** A unit of measure of the quantity of light. One lumen is amount of light that falls on an area of one square foot every point of which is one foot from the source of one candela (candle).

- **Footcandle (fc)**: The unit of illuminance = the luminous flux per square foot on a sphere of radius 1 foot. One footcandle is approximately 10 lux.
- **Lux**: The unit of illuminance = the luminous flux per unit area of 1 square meter on a sphere of radius 1 meter.
- **Luminance (L):** The luminous intensity of a surface in a given direction per unit of projected area of the surface as viewed from taht direction.
- **Candela (cd):** The unit of luminous intensity. Formerly the term “candle was used.
- **Illuminance**: The density of the luminous flux incident on a surface. It is the quotient of luminous flux by area of the surface when the latter is uniformly illuminated.

2. Equipment terms:

Current terminology relating to hardware and its mounting include the following:

- **Lamp**: A generic term for a man-made source of light and which is produced either by incandescence or luminescence.

- **Efficacy, Luminous efficacy**: The quotient of the total luminous flux delivered from a light source divided by the total power input to the light source. It is expressed in lumens per watt.

- **Ballast**: A device used with an electric-discharge lamp to obtain the necessary circuit conditions (voltage, current and wave form) for starting and operating.
- **Luminaire**: A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps and to connect the lamps to the power supply.
- **Mounting Height (MH):** the vertical distance between the roadway surface and the center of the apparent light source of the luminaire (fixture position relative to the edge of the roadway).
- **Lighting standard:** the pole with or without bracket or mast arm used to support one or more luminaries.
- **Bracket or arm**: An attachment to a lighting standard or other structure used for the support of a luminaire.
- **Spacing**: The distance between successive lighting units measured along the centerline of the roadway.

3. **Luminaire and Light distribution** terms relating to data on luminaries and on light distributions include the following:

- **Transverse Roadway Lines (TRL):** One set of lines that establish a coordinate system for roadway lighting analysis. This set runs perpendicular to the curbline or edge of pavement.
- **Longitudinal Roadway Lines (LRL**): Another set of lines used in the coordinate system. This set runs parallel to the curbline of the roadway.(www.urban design manual.pdf)

APPENDIX B

Enerji ve Tabii Kaynaklar Bakanlığı'ndan:
ELEKTRIK DIŞ AYDINLATMA YÖNETMELIĞI

Birinci Bölüm

Amaç, Kapsam, Hukuki Dayanak ve Tanımlar
AMAÇ
Madde - 1:
Bu yönetmeliğin amacı, elektrik enerjisinin nihai tüketiminde önemli payı olan dış aydınlatmada, enerjinin etkin ve doğru kullanılmasıyla gereksiz yere enerji sarfiyatını önleyerek enerji tasarrufu sağlanması ve astronomik gözlemleri ve doğal hayatı olumsuz yönde etkileyen ışık kirliliğinin önlenmesidir.
KAPSAM
Madde - 2:
Bu yönetmelik, aydınlatmanın kalitesinden ve güvenliğinden ödün vermeden enerji tasarrufu sağlayacak şekilde, kentsel yerleşik alanlardaki bina, tesis, yol, cadde ve sokaklar ile milli park, vb. tabiatı koruma alanları, kentsel gelişme alanları ve turizm ve ticaret alanlarının dış aydınlatmalarında kullanılan aydınlatma armatürlerinin ve ışık kaynaklarının (lambaların) tiplerinin, teknik ve fotometrik özelliklerinin, konumlarının ve tesisatının belirlenmesinde uyulması gereken kuralları kapsar.
Türk Silahlı Kuvvetlerine ait harekat ve savunma amaçlı aydınlatmalar, askeri yasak bölgeler güvenlik bölgelerindeki aydınlatmalar ile kendi yönetmeliğine uygun olarak tesis edilen havaalanı ve benzeri tesisler bu yönetmelik kapsamı dışındadır.
HUKUKİ DAYANAK
Madde - 3:
Bu yönetmelik, 3154 sayılı Enerji ve Tabii Kaynaklar Bakanlığı'nın Teşkilat ve Görevleri Hakkındaki Kanun'un 28'inci Maddesinin verdiği yetkiye dayanarak aynı kanunun 2'inci Maddesinin (b) bendi ile 12/8/1993 tarihli ve 505 sayılı Kanun Hükmünde Kararname ile değişik 10'uncu Maddesinin (d) bendi uyarınca hazırlanmıştır.
TANIMLAR
Madde - 4:
Bu Yönetmelikte yer alan kısaltmalar ve tanımlamalar aşağıda verilmektedir.

a. **Bakanlık :** Enerji ve Tabii Kaynaklar Bakanlığı
b. **Yetkili Kuruluş :** Dış aydınlatma tesisine elektrik enerjisi sağlayan elektrik dağıtım şirketidir.
c. **Dış Aydınlatma Tesisi :** Dış aydınlatma yapmak üzere kurulmuş olup, Elektrik Kuvvetli Akım Tesisleri Yönetmeliği kapsamında olan bir kuvvetli akım tesisidir.
d. **Yerleşme Alanı :** İmar planı sınırı içindeki yerleşik ve gelişme alanlarının tümüdür (3194 sayılı İmar Kanunu ve ilgili yönetmelikler).
e. **Mücavir Alan :** İmar mevzuatı bakımından belediyelerin kontrol ve mesuliyeti altına verilmiş olan alanlardır.
f. **Yerleşik (Meskun) Alan : a)** Planlı yerlerde; nazım imar planı ile belirlenmiş ve iskan edilmiş alanlar, **b)** Plansız yerlerde, belediye ve mücavir alan sınırları içindeki imar planı bulunmayan mevcut yerleşmelerin (mahalle, köy ve mecralar) müstakbel gelişme alanlarını da içine alan ve sınırları belediye meclislerince karara bağlanan alanlardır.
g. **Gelişme (İnkişaf) Alanı :** Nazım imar planında kentin gelişmesine ayrılmış olan alanlardır.
h. **Kentsel Çalışma Alanları : a)** Ticaret Bölgesi; imar planlarında ticari amaçlı yapılar için ayrılmış bölgedir (Bu bölgede bürolar, işhanları, gazino, lokanta, çarşı, çok katlı mağazalar, bankalar, oteller, sinema ve tiyatro gibi kültürel ve sosyal tesisler, yönetimle ilgili tesisler ve benzeri yapılar yapılabilir). **b)** Sanayi Bölgesi; imar planlarında her türlü sanayi tesisleri için ayrılmış alanlardır (Bu bölge içerisinde amaca göre hizmet görecek diğer yapı ve tesisler de yapılabilir).
i. **Turizm Bölgeleri :** Sınırları Turizm Bakanlığı'nın önerisi ve Bakanlar Kurulu kararı ile tespit ve ilan edilen bölgelerdir (2634 sayılı Turizmi Teşvik Kanunu ve ilgili yönetmelik).
j. **Turizm Alanları :** Turizm bölgeleri içinde öncelikle geliştirilmesi öngörülen, mevkii ve sınırları Turizm Bakanlığı'nın önerisi ve Bakanlar Kurulu kararı ile tespit ve ilan edilen, doğal veya sosyo-kültürel değerlerin yoğunlaştığı alanlardır.

k. **Turizm Merkezleri :** Turizm bölgeleri içinde veya dışında, yeri, mevkii ve sınırları Turizm Bakanlığı'nın önerisi ve Bakanlar Kurulu kararı ile tespit ve ilan edilen, turizm bakımından önem taşıyan yerler ve bölümlerdir.

l. **Koruma Alanı :** Taşınmaz kültür ve tabiat varlıklarının muhafazaları veya tarihi çevre içinde korunmalarında etkinlik taşıyan korunması zorunlu olan alanlardır (2863 sayılı Kültür ve Tabiat Varlıklarını Koruma Kanunu, 2873 sayılı Milli Parklar Kanunu).

m. **CIE :** Uluslararası Aydınlatma Komisyonu (Commission Internationale de L'eclairage)

n. **Işık Kirliliği :** Işığın, enerji savurganlığına neden olacak, astronomi gözlemlerini engelleyecek ve doğal hayatı bozucu tehlikeler oluşturacak şekilde, yanlış yerde, yanlış miktarda, yanlış yönde ve yanlış zamanda kullanılmasıdır.

o. **Işık akısı (f) :** Bir ışık kaynağının ışık akısı, bu ışık kaynağından çıkan ve normal gözün gündüz görmesine ait spektral duyarlık eğrisine göre değerlendirilen enerji akısıdır. Birimi lümen (lm) dir.

p. **Uzay açı (W) :** İçinden kısmi ışık akısı geçen koni veya piramit şeklindeki uzay parçasına denir. Birimi steradyan (sr) dır.

r. **Işık şiddeti (I) :** Noktasal ışık kaynağının belli bir a doğrultusundaki ışık şiddeti, bu doğrultuyu içine alan D W uzay açısından çıkan D f ışık akısının D W uzay açısına bölümü ile ilgilidir. D W sıfıra yaklaşırken bu oranın limiti ışık şiddetini tanımlar. Birimi candela (cd) dır.

s. **Işık Dağılım (Polar Fotometri) Eğrisi :** Noktasal bir ışık kaynağından geçen düzlem üzerinde, kaynağın çeşitli doğrultulardaki ışık şiddetlerinin uç noktalarının geometrik yeridir.

t. **Armatür Verimi (h) :** Bir aydınlatma armatüründen çıkan ışık akısının armatür içindeki lambanın ürettiği ışık akısına oranıdır.

u. **Üst Yarı Uzay Işık Akısı Oranı (ULOR) :** Armatürün üst yarı uzaya yaydığı ışık akısının, içindeki lambanın ürettiği ışık akısına oranıdır.

v. **Alt Yarı Uzay Işık Akısı Oranı (DLOR) :** Armatürün alt yarı uzaya yaydığı ışık akısının, içindeki lambanın ürettiği ışık akısına oranıdır.

y. **Aydınlık Şiddeti (E) :** Yüzeye düşen ışık akısının, o yüzeyin alanına bölümüdür. Birimi lüks (lx) tür.

z. **Kamaşma :** Sağlam bir gözün dış etkilerle geçici olarak etrafındaki cisimleri göremez hale gelmesine denir. Aynı nedenlerle oluşmalarına rağmen, etkileri farklı olan psikolojik ve fizyolojik kamaşma olmak üzere iki tip kamaşma vardır. Psikolojik kamaşma, görme yeteneğinde herhangi bir azalma olmaksızın, kullanıcıda hoş olmayan duygular yaratan ve konforu bozan kamaşma tipidir. Fizyolojik kamaşma ise gözün görme yeteneğini bozan tiptir.

aa. **Koruma Derecesi :** Aydınlatma armatürlerinin toza, katı cisimlere ve suya, neme karşı dayanıklıklarının göstergesidir. Uluslararası kabullere göre IPX_1X_2 kodları ile gösterilir. Koruma derecesindeki ilk rakam (X_1) katı cisimlere, ikinci rakam (X_2) ise suya karşı koruma derecesini gösterir (TS 3033).

bb. **Parıltı (L) :** Işık yayan bir yüzeyin bir noktasının, bu yüzeyin normali ile a açısı yapan doğrultudaki parıltısı, bu noktayı içine alan yüzey elemanının bu doğrultuda doğurduğu ışık şiddetinin, bu doğrultuya dik düzlemdeki yüzeyin görünen alanına oranının limitidir. Birimi cd/m^2 'dir.

cc. **Ekranlı Armatür :** Maksimum ışık şiddeti düşeyle 65° lik açıda sınırlandırılmış, üst yarı uzaya hiç ışık yaymayan (ULOR = 0) aydınlatma armatürü.

dd. **Yarı-ekranlı Armatür :** Maksimum ışık şiddeti düşeyle 75° lik açıda sınırlandırılmış, üst yarı uzaya gönderdiği ışık akısı % 10'dan fazla olmayan (ULOR £ %10) aydınlatma armatürü.

ee. **Ekransız Armatür :** Maksimum ışık şiddeti belli bir açı ile sınırlandırılmamış olan, ancak düşeyle 90° lik açıda ışık şiddeti, içindeki lambanın/lambaların ışık akısı ne olursa olsun, 1000 cd'yı aşmayan armatür.

ff. **Ekonomik Ömür :** Bir tesisteki lambaların 100 saat kullanımdan sonraki toplam ışık akılarının, lambaların kullanılmaz hale gelmeleri ve ışık akılarındaki azalmalarından dolayı yaklaşık % 30 değer kaybettiği ana kadar geçen süredir.

gg. **Etkinlik Faktörü (e) :** Bir ışık kaynağının etkinlik faktörü, kaynaktan çıkan toplam ışık akısının kaynağın gücüne oranıdır. Birimi lümen/watt (lm/W) dır.

DIŞ AYDINLATMADA TEMEL PRENSİPLER

Madde – 5:

Aydınlatmadan azami ölçüde yararlanılabilmesi ve yaşanılan ortamda gerekli güvenliğin temini ön planda tutularak gereken enerji tasarrufunun sağlanabilmesi ve ışık kirliliğinin önlenebilmesi için tasarımdan kullanıma kadar tüm safhalarda uyulması gereken temel prensipler aşağıda sıralanmıştır;

İlgili standartlar ve Uluslararası Aydınlatma Komisyonu'nun yayınları da takip edilerek aydınlatılacak yere ve amaca uygun optimum çözümün elde edilebileceği aydınlatma kriterlerinin belirlenmesi,

a. Fotometrik ve teknik özellikleri bilinen armatürler ile gerekli tasarım hesaplarının yapılması, sadece aydınlatılacak alana ışık gönderen armatür tip ve sayılarının saptanması,
b. Aydınlık şiddeti algılayıcılı ve/veya zaman kontrollu tesisat ile aydınlatmanın gerek duyulan zamanlarda gerektiği ölçüde yapılmasının sağlanması.

IŞIK KAYNAKLARI (LAMBALAR)

Madde – 6:

Yönetmeliğin yayımı tarihinde geçerli olan teknolojik olanaklar esas alınarak, dış aydınlatmada kullanılabilecek ışık kaynaklarının (lambaların) teknik özellikleri ve kullanım alanları aşağıda açıklanmıştır. Teknolojik gelişmeler sonucunda oluşacak üstünlükler zaman içinde değerlendirilip lambaların kullanımına yansıtılacaktır.

a. **Akkor Telli (Enkandesen) Lambalar :** Etkinlik faktörleri çok düşük (~ 15 lm/W), ömürleri kısa, fakat renksel özellikleri mükemmel olan bu ışık kaynakları (lambalar) dış aydınlatma amacına uygun değildir. Bu lambalar sadece kısa süreler için gerçekleştirilen eğlence, reklam amaçlı aydınlatmalarda çok iyi ekranlanmış armatürler içinde kullanılabilir. Şu an için var olan akkor telli lambalı tesisat, ömürleri sonunda Yönetmeliğe uygun farklı bir lamba grubu ile değiştirilecektir.
b. **Kompakt Flüoresan Lambalar :** Akkor telli lambaların alternatifi olarak üretilen bu ışık kaynaklarının (lambaların) etkinlik faktörleri (~ 60 lm/W) akkor telli lambalardan daha yüksek ve ömürleri daha uzundur. Sadece park, bahçe, kapı önü aydınlatması amaçlı kullanılacak olan bu lambaların, çalışma karakteristikleri ortam sıcaklığına bağlı olarak değişmektedir. Bu nedenle kompakt flüoresan lambalı dış aydınlatma tesislerinde kullanılan lambalar dış ortam koşullarına uygun tiplerden seçilecek ve çok iyi korumalı armatürler içine yerleştirilecektir. Balastın lambanın içinde yer almadığı durumlarda, standartlara uygun elektronik balastlar kullanılacaktır.
c. **Tüp Flüoresan Lambalar :** Etkinlik faktörleri 80 lm/W civarında olan uzun ömürlü bu ışık kaynaklarının (lambaların) da çalışma karakteristikleri ortam sıcaklığından çok etkilenmektedir. Verimli bir aydınlatma yaratılabilmesi için bu lambalar da yine dış ortam koşullarına uygun olan tiplerden seçilecek ve iyi korumalı armatürler içine yerleştirilecektir. Standartlara uygun elektronik balastlar kullanılacaktır. Lambalar kesinlikle armatürsüz, çıplak olarak kullanılmayacaktır. Uygun armatürler ile ışıkları tamamen aydınlatılan yüzeye yönlendirilmiş olacaktır. Parıltıları oldukça düşük olan ve çıplak gözle bakılabilen bu lambalar sadece reklam ve seyir amaçlı aydınlatmalarda uygun düzeneklerle görünür şekilde kullanılabilir. Tüp flüoresan lambalar kesinlikle yol, cadde, sokak, meydan aydınlatması amaçlı kullanılmayacaktır.
d. **Yüksek Basınçlı Civa Buharlı Lambalar :** Etkinlik faktörleri 50 lm/W civarında olan beyaz ışıklı bu lambalar sadece park, bahçe aydınlatması için kullanılacaktır. Lambalar üst yarı uzaya hiç ışık göndermeyecek şekilde tasarlanmış ekranlı armatürler içine yerleştirilecektir.
e. **Metal Halojen Lambalar :** Etkinlik faktörleri 80 lm/W civarında ve renk özellikleri iyi olan bu lamba grubu özel aydınlatmalar için uygundur. Ekonomik ömürleri kısa olan bu lambalar sadece renkli TV çekimlerinin yapılacağı açık hava spor sahalarında ve beyaz rengin vurgulanmak istendiği bina dış cephe aydınlatmalarında, çok iyi ekranlanmış armatürler içinde kullanılacaktır.
f. **Yüksek Basınçlı Sodyum Buharlı Lambalar :** Bu lambalar en uzun ömürlü ışık kaynakları (lambalar) olup, şeffaf cam tüplü olanlarının etkinlik faktörleri 130 lm/W civarındadır. Şehir içi yol, cadde, sokak, meydan aydınlatmalarının tamamında parlak beyaz-sarı renkte ışık yayan bu lambaların en verimli tipi olan şeffaf cam tüplüleri kullanılacaktır. Daha önce yüksek basınçlı civa buharlı lambalı tesislerde enerji tasarrufu elde edebilmek amacıyla kullanılmış olan yüksek basınçlı sodyum buharlı lambaların ateşleyicisiz tipi yeni tesislerde kesinlikle kullanılmayacaktır.
g. **Alçak Basınçlı Sodyum Buharlı Lambalar :** Renk ayırımının önemli olmadığı tüm tesislerde kullanılabilecek en yüksek etkinlik faktörlü ışık kaynağıdır. Ekspres yollar, limanlar, yükleme boşaltma alanları ve güvenlik aydınlatması için uygun lambalardır. Işık kirliliğinin önlenmesinin birinci derecede önem taşıdığı doğal hayatın korunması gereken alanlardaki ve astronomi gözlemevleri etrafındaki yol, sokak, meydan, alan aydınlatmalarında sadece alçak basınçlı sodyum buharlı lambalar kullanılacaktır.

ARMATÜRLER
Madde - 7:
Dış aydınlatmada kullanılacak armatürler, verimi yüksek ve koruma derecesi en az IP 54 olan tiplerden seçilecektir. Armatürlerin her birinin içinde güç katsayısını en az 0,95 olacak şekilde ayarlayan tekil veya merkezi kompanzasyon üniteleri bulunacaktır.
Armatürler ve donanımları, Ek-1'de listelenen ilgili standartlara uygun olmalıdır.
Armatürlerin üst yarı uzaya (gökyüzüne) gönderdikleri ışık miktarı, Madde–8'de verilen yüzdeleri aşmayacak ve ışık dağılım eğrileri de kamaşma problemine yol açmayacak şekilde ekranlanmış olacaktır.
Fotometrik ölçümler Uluslararası Aydınlatma Komisyonu'nun Ek–2'de listelenen yayınlarına göre yapılacaktır.
10 m'den alçak direklerle yapılan uygulamalarda, kullanılan armatürlerin düşeyle 85° lik açı yapan doğrultudaki ışık şiddeti değerleri Tablo 1'deki değerleri aşmayacaktır.

Tablo 1. 10 metreden alçak direk yüksekliklerinde kamaşma sınırlaması

Düşeyle 85° lik açıda ve üstünde parıltı değeri	£ 20 000 cd/m^2		
Direk yüksekliği	< 4,5 m	4,5m ~ 6,0m	6m ~ 10m
85° lik açıda ışık şiddeti	£ 2 500 cd	£ 5 000 cd	£ 12 000 cd

10 m'den yüksek direklerle yapılan aydınlatmalarda ise, Ek-4'te verilen aydınlatma kriterleri sağlanacaktır.
Ek-5'de cadde, sokak, gezinti yolları, park ve bahçelerde kullanılan aydınlatma armatürlerinin bazı tiplerinin ışık dağılım eğrileri, alt ve üst yarı uzaya gönderdikleri ışık akısı yüzdeleri gösterilmektedir.
Park ve bahçelerde büyük ölçüde üst yarı uzaya ışık gönderen glop (küre) tipi armatürler kullanılmayacaktır. Glop tipi armatürler ancak uygun ekranlarla ışıkları alt yarı uzaya yönlendirildiğinde kullanılabilir. Ek-6'da ekransız ve ekranlı glop tipi armatürlerin ışık akıları yüzdeleri verilmektedir.
Bina dış cephe ve reklam panoları aydınlatılması amaçlı kullanılan projektör tipi armatürler uygun açılarla sadece aydınlatılmak istenen alanı aydınlatacak tipte seçilecek ve yönlendirilecektir. Aydınlatmalar yukarıdan aşağıya doğru yapılacaktır.
Üçüncü Bölüm
Aydınlatma Bölgeleri
AYDINLATMA BÖLGELERİ
Madde - 8:
Güvenlik, ulaşım, ticari ve turizm gereksinimleri dikkate alınarak, gerek enerji tasarrufu sağlanması gerekse doğal hayatın ve astronomik gözlemlerin etkilenmemesi amacıyla dış aydınlatma uygulamalarında aşağıda belirtilen kurallar esas alınır.
I. Bölge : Gözlemevleri çevresindeki 30 km. yarıçaplı alanlar, köy ve mezralar hariç yerleşme alanları dışında kalan alanlar ile doğal hayatın, tarihi ve kültürel yapının korunması gereken koruma alanlarını kapsar. Bu bölgelerde üst yarı uzaya gönderdikleri ışık akısı yüzdeleri % 0 (ULOR=% 0) olan yüksek verimli armatürler içinde sadece alçak basınçlı sodyum buharlı lambalar kullanılacaktır.
II. Bölge : Belediye mücavir alanları ile kentsel çalışma ve gelişme alanları, imar ve yol istikamet planı bulunmayan beldeler ve köy sınırlarını kapsar. Bu bölgede kullanılacak armatürlerin üst yarı uzaya gönderdikleri ışık akısı yüzdeleri % 5'den az (ULOR £ %5) olacaktır.
III. Bölge : 3030 Sayılı Kanun kapsamındaki Büyükşehir Belediyeleri ve 1580 Sayılı Kanun kapsamındaki diğer belediyelerin sınırları içindeki kentsel yerleşik ve gelişme alanları ile mücavir alanları kapsar. Bu bölgelerde güvenlik amaçlı yol aydınlatması armatürlerinin üst yarı uzaya yaydıkları ışık akısı % 5'den az (ULOR £ %5), eğlence ve reklam amaçlı dış aydınlatma armatürlerinin üst yarı uzaya gönderdikleri ışık akısı yüzdeleri ise % 15'den az (ULOR £ %15) olacaktır.
IV. Bölge : Dış aydınlatmanın ve reklam aydınlatmalarının yoğun olarak kullanılması gerekli olan kentsel çalışma alanlarından ticaret bölgelerini ve turizm bölgelerini kapsar. Bu bölgelerde, güvenlik amaçlı yol aydınlatmaları için kullanılan armatürlerin üst yarı uzaya gönderdikleri ışık akısı yüzdeleri % 5'den az (ULOR£ %5) olmalıdır; turizm ve ticaret amaçlı sürekli aydınlatmalarda kullanılan armatürlerin üst yarı uzaya gönderdikleri ışık akısı yüzdeleri en fazla %15 (ULOR £ %15) olmalıdır. Yine turizm ve ticaret amaçlı olarak ve kısa süreler için yapılacak aydınlatmalarda ise, armatürlerin üst yarı uzaya gönderdikleri ışık akısı yüzdelerinin en fazla %20 (ULOR £ %20) olmasına müsaade edilebilir.

Dördüncü Bölüm
Plan ve Projelerin Onaylanması, Uygulama ve Denetim,
Geçici Muafiyet ve Süresi,
Yaptırım, Yürütme ve Yürürlük

PLAN VE PROJELERİN ONAYLANMASI

Madde - 9 :

Dış aydınlatma tesisini kurmak isteyen kişi veya kuruluşlar özel veya tüzel kişilere hazırlattıkları uygulama projeleriyle birlikte, projenin kurulu gücüne göre Enerji ve Tabii Kaynaklar Bakanlığı'na veya yetkili kuruluşa başvurmak zorundadır. Projeler mutlaka aşağıdaki belgeleri içermelidir;

1. Işık kaynaklarının (lambaların), aydınlatma armatürlerinin ve taşıyıcıların tiplerini ve konumlarını gösteren paftalar,
2. Işık kaynakları (lambalar), aydınlatma armatürleri ve taşıyıcıların teknik ve fotometrik (ışık dağılım eğrileri, verimi, üst ve alt yarı uzay ışık akısı yüzdeleri, parıltısı, v.b.) özelliklerini içeren bilgi ve açıklamalar,
3. Kullanılan armatürlerin fotometrik değerleri ile yapılmış, armatür sayısını, yerlerini, yönlendirme açılarını ve sağlanacak aydınlatma kriterlerini veren aydınlatma tasarım hesapları,
4. Elektrik kuvvetli akım tesis projesi.

Projelerin Bakanlık ya da yetkili kuruluş tarafından kontrolü ve iki ay içinde cevaplandırılması zorunludur.

UYGULAMA VE DENETİM

Madde – 10:

Onaylanmış projelerin uygulamadaki denetlenmesi yetkili kuruluşların sorumluluğundadır. Bu yönetmeliğe uymayan lamba ve armatür çeşitleri kullanılamaz.

Bu yönetmeliğin yürürlüğe girdiği tarihten önce, yasa ve yönetmeliklere uygun olarak kurulmuş ve çalışır durumda olan bütün dış aydınlatma tesisleri ile onay alınarak uygulama aşamasına gelmiş olan projeler, bu yönetmelik kapsamı dışındadır. Ancak, yönetmeliğin yürürlüğe girdiği tarihten itibaren, mevcut tesislerdeki ışık kaynakları (lambalar) ekonomik ömürleri sonunda, tesis değişikliği gerektirmeyen daha verimli tipleriyle, bu yönetmeliğe uygun olarak değiştirilecektir.

GEÇİCİ MUAFİYET VE SÜRESİ

Madde – 11:

Tesis sahibi veya işletmecisi, yazılı bir dilekçe ile bu yönetmelikle ilgili hususlarda geçici muafiyet için başvurabilir. Geçici muafiyet için başvurular aşağıdaki bilgileri içerecektir;

1. İstenen özel muafiyet(ler),
2. İstenen özel muafiyet(ler)in süresi,
3. Varsa önceki geçici muafiyet(ler) ve ilgili yer adresleri,
4. Işık kaynaklarının (lambaların) tipi, gücü ve ışık akısı,
5. Işık kaynaklarının (lambaların) toplam gücü (W),
6. Söz konusu dış aydınlatma armatürünün (armatürlerinin) tipi ve teknik özellikleri (boyut, ekran, v.b.),
7. Dış aydınlatma armatürünün (armatürlerinin) konacağı yer ve yönlendirme açısı,
8. Dış aydınlatma armatürünün (armatürlerinin) fotometrik özellikleri,
9. Yetkili kuruluşun gerekli gördüğü benzeri diğer bilgiler.

Yetkili kuruluş tarafından, geçici muafiyet başvurusuna, veriliş tarihinden sonra otuz gün içinde cevap verilecek ve geçici muafiyet onay tarihinden itibaren en fazla altı ay için geçerli olacaktır.

YAPTIRIM

Madde – 13:

Bu yönetmelikle belirtilen şartlara uymadığından tesis izni alamayan veya izin için başvuruda bulunmayan tesislere enerji verilmeyeceği gibi, yönetmeliğe uymadığı belirlenen tesislere verilmiş bulunan enerji, yetkili kuruluş tarafından kesilir.

YÜRÜTME

Madde – 14:

Bu yönetmeliği Enerji ve Tabii Kaynaklar Bakanlığı yürütür.

YÜRÜRLÜK

Madde – 15:

Bu yönetmelik Resmi Gazete'de yayımlandığı tarihten itibaren yürürlüğe girer.

EK 4. DEĞİŞİK YOL TİPLERİ İÇİN ÖNERİLEN AYDINLATMA KRİTERLERİ

Değişik yol tipleri için güvenlik ve konfor açısından sağlanması gereken aydınlatma kriterleri aşağıdaki tablolarda verilmektedir.

Tablo E1. Farklı yol tipleri için aydınlatma sınıfları

Yolun Tanımı	Aydınlatma Sınıfı
Bölünmüş yollar, ekspres yollar, otoyollar (otoyola giriş ve çıkışlar, bağlantı yolları, kavşaklar, ücret toplama alanları) Trafik yoğunluğu ve yolun karmaşıklık düzeyi (Not 1); Yüksek……………………………………………… Orta…………………………………………………. Düşük………………………………………………..	M1 M2 M3
Devlet yolu ve il yolları (tek yönlü veye iki yönlü; kavşaklar ve bağlantı noktaları ile şehir geçişleri ve çevre yolları dahil) Trafik kontrolu (Not 2) ve yol kullanıcılarının (Not3) tiplerine göre ayrımı (Not 4); Zayıf………………………………………………… İyi…………………………………………………….	M1 M2
Şehir içi ana güzergahlar (bulvarlar ve caddeler), ring yolları, dağıtıcı yollar Trafik kontrolu (Not 2) ve yol kullanıcılarının (Not 3) tiplerine göre ayrımı (Not 4); Zayıf………………………………………………… İyi…………………………………………………….	M2 M3
Şehir içi yollar (yerleşim alanlarına giriş çıkışn yapıldığı ana yollar ve bağlantı yolları) Trafik kontrolu (Not 2) ve yol kullanıcılarının (Not 3) tiplerine göre ayrımı (Not 4); Zayıf………………………………………………… İyi…………………………………………………….	M4 M5

Not 1. Karmaşıklık; Yolun geometrik yapısını, trafik hareketlerini ve görsel çevreyi içerir. Gözönünde bulundurulması gereken faktörler; şerit sayısı, yolun eğimi, trafik ışık ve işaretleri.
Not 2. Trafik kontrolu; Yatay ve düşey işaretlemeler ve sinyalizasyon ile trafik mevzuatının varlığı anlamında kullanılmıştır. Bunların olmadığı yerlerde trafik kontrolu zayıf olarak adlandırılır.
Not 3. Kullanıcılar; Motorlu araçlar (kamyon, otobüs, otomobil vb.), bisiklet, yavaş araçlar ve yayalar.
Not 4. Ayrım; Tahsisli yol (Herbir trafik cinsinin kullanacağı şeridin kesin olarak ayrıldığı yerler, örneğin otobüs yolu, bisiklet yolu vb.).
Tablo E1'de tanımlanan aydınlatma sınıfları için parıltı, enine ve boyuna düzgünlük oranları ve kamaşma sınırlaması ile ilgili değerler Tablo E2'de gösterilmektedir.

Tablo E2. Değişik aydınlatma sınıfları için uygulanacak yol aydınlatması kriterleri

Aydınlatma sınıfı	L (cd/m²)	U_o	U_l	TI (%) £
M1	2.0	0.4	0.7	10
M2	1.5	0.4	0.7	10
M3	1.0	0.4	0.5	10
M4	0.75	0.4	-	15
M5	0.5	0.4	-	15

Burada;
U_o : Ortalama Düzgünlük : Yolun sağ kenarından yol genişliğinin ¼ mesafesinde bulunan bir gözlemciye göre kısmi alanların minimum parıltısının yolun ortalama parıltısına oranıdır ($U_o = L_{min} / L_{ort}$).
U_l : Boyuna Düzgünlük : Her yol şeridinin orta çizgisi üzerinde bulunan gözlemci noktasına göre, bu orta çizgi boyunca uzanan kısmi alanlardaki minimum parıltının maksimum parıltıya oranıdır ($U_l= L_{min} / L_{max}$).
TI : Bağıl Eşik Artışı : Fizyolojik kamaşmanın neden olduğu görülebilirlik azalmasının ölçüsüdür. Kamaşma koşullarındaki parıltı eşiği D L_K ile kamaşma olmadığındaki D L_e eşik farkının D L_e'ye oranı olarak ifade edilir (TI = { D L_K - D $L_{e\}}$ / D L_e) .
Yaya trafiği olan alanlardaki değişik yol tipleri için tanımlanan aydınlatma sınıfları Tablo E3'de ve bu aydınlatma sınıfları için uygulanacak ortalama aydınlık şiddeti değerleri ise Tablo E4'de verilmektedir.

Tablo E3. Yaya alanlarındaki değişik yol tipleri için aydınlatma sınıfları

Yolun Tanımı	Aydınlatma Sınıfı
Sosyo-ekonomik ve kültürel önemi yüksek olan kalabalık yaya yolları	P1
Trafiği yüksek yaya veya bisiklet yolları	P2
Trafiği orta yaya veya bisiklet yolları	P3
Trafiği az yaya veya bisiklet yolları	P4
Doğal çevrenin, tarihi ve kültürel yapının korunması gereken alanlardaki trafiği az yaya veya bisiklet yolları	P5
Doğal çevrenin, tarihi ve kültürel yapının korunması gereken alanlardaki trafiği çok az yaya veya bisiklet yolları	P6

Tablo E4. Yaya yolları için önerilen aydınlık düzeyi değerleri

Aydınlatma Sınıfı	Ortalama Aydınlık Düzeyi (lux)
P1	20
P2	10
P3	7.5
P4	5
P5	3
P6	1.5

Tanımlar:
Bölünmüş Yol (Tek Yönlü Yol); Taşıt yolunun yalnız bir yöndeki taşıt trafiği için kullanıldığı karayoludur.
Ekspres Yol; Sınırlı erişme kontrollu ve önemli kesişme noktalarının köprülü kavşak olarak teşkil edildiği bölünmüş karayoludur.
Otoyollar; Özellikle transit trafiğe tahsis edilen, belirli yerler ve şartlar dışında geçiş ve çıkşın yasaklandığı, yaya, hayvan ve motorsuz araçların giremediği, ancak izin verilen motorlu araçların yararlandığı ve trafiğin özel kontrole tabi tutulduğu erişme kontrollu karayoludur.
İki Yönlü Yol; Taşıt trafiğinin her iki yönde kullanıldığı karayoludur.
Geometrik Yapı; Yolun sınıfına göre tasarım şeklidir (yolun genişliği, şerit sayısı, yatay ve düşey eğim, yolun proje hızı vb.).
Trafik Yoğunluğu; Yayaların, hayvanların ve araçların karayolları üzerindeki hareketleridir.
Trafik Güvenliği; Karayolları trafik kanunu ve buna dayanılarak çıkartılan ilgili mevzuat.
Kullanıcılar; Motorlu taşıtlar, motorsuz taşıtlar, yayalar ve hayvanlardır.
Kavşak; İki veya daha fazla yolun kesişmesi veya birleşmesi ile oluşan ortak alandır.
Bağlantı Yolu; Bir kavşak yakınında, karayolu taşıt yollarının birbirine bağlanmasını sağlayan, kavşak alanı dışında kalan ve bir yönlü trafiğe ayrılmış olan karayolu kısmıdır.

APPENDIX C.1
Questionnaire for Outdoor Lighting Quality Analysis
For Residents

Residential Area:
Occupation:
Age:

SAFETY&SECURITY

1. Does the lighting arrangement encourage safe use of the public realm?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

2.Does the lighting adequately illuminate pedestrian spaces and possible entrapment areas? Are there areas in the residential areas that are too dark?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

3. Do you feel exterior lighting prevent crime?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

SENSE OF PLACE

4. Does the lighting arrangement contribute to the creation of an established or need to new sense of place?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

5. Are lighted used in all areas where nighttime activities appropriate for social interaction?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

CIRCULATION

6.Are the nighttime routes identified and adequately lighted?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

7. Do the corridors provide nighttime adequate illumination for orient to the people?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

FACILITIES

8.What do you think of the existing lighting in parks on a scale of 0 to 3?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

9. What do you think of the existing lighting in parking areas on a scale of 0 to 3?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

10. What do you think of the existing lighting in pedestrian paths on a scale of 0 to 3?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

11. What do you think of the existing lighting in vehicular roads on a scale of 0 to 3?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

APPENDIX C.2

Questionnaire for Outdoor Space Lighting Quality Analysis
For Local Professionals

Residential Area:
Institution:
Occupation:

STRUCTURAL DESIGN

1.Does the existing illumination in residential area provide uniformity?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

2. Is the hierarchy of lighting appropriate for each different activity areas?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

3. Is there the consistency between types of existing lighting fixtures?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

TECHNICAL DESIGN

4. Are the lamps used in all areas appropriate?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

5. Does the color of illumination provide comfortably visibility?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

6. Cut off luminaires prevent light pollution. Are the non-cut off or semi cut of luminaires be used in your neighbouhood?Are there areas in the residential areas too bright at night?

0 (None) 1 (Poor) 2 (Average= Moderate) 3(Excellent)

APPENDIX D.1
EVKA 3 Questionnaire Results (Residents)

Question 1	
Mean	**1,67**
Standard Error	0,13841
Median	2
Mode	1
Standard Deviation	**0,71810**
Sample Variance	0,57471
Kurtosis	-0,91143
Skewness	0,65955
Range	2
Minimum	1
Maximum	3
Sum	50
Count	30

Question 2	
Mean	**1,27**
Standard Error	0,08212
Median	1
Mode	1
Standard Deviation	**0,44978**
Sample Variance	0,20230
Kurtosis	-0,82386
Skewness	1,11166
Range	1
Minimum	1
Maximum	2
Sum	38
Count	30

Question 3	
Mean	**2,17**
Standard Error	0,14450
Median	2
Mode	3
Standard Deviation	**0,69148**
Sample Variance	0,62644
Kurtosis	-1,30900
Skewness	-0,31462
Range	2
Minimum	1
Maximum	3
Sum	65
Count	30

Question 4	
Mean	**0,13**
Standard Error	0,06312
Median	0
Mode	0
Standard Deviation	**0,34575**
Sample Variance	0,11954
Kurtosis	3,38599
Skewness	2,27252
Range	1
Minimum	0
Maximum	1
Sum	4
Count	30

Question 5	
Mean	**1,30**
Standard Error	0,08510
Median	1
Mode	1
Standard Deviation	**0,46609**
Sample Variance	0,21724
Kurtosis	-1,24213
Skewness	0,91950
Range	1
Minimum	1
Maximum	2
Sum	39
Count	30

Question 6	
Mean	**1,27**
Standard Error	0,08212
Median	1
Mode	1
Standard Deviation	**0,44978**
Sample Variance	0,20230
Kurtosis	-0,82386
Skewness	1,11166
Range	1
Minimum	1
Maximum	2
Sum	38
Count	30

Question 7	
Mean	**1,20**
Standard Error	0,07428
Median	1
Mode	1
Standard Deviation	**0,40684**
Sample Variance	0,16552
Kurtosis	0,52745
Skewness	1,58013
Range	1
Minimum	1
Maximum	2
Sum	36
Count	30

Question 8	
Mean	**1,03**
Standard Error	0,12208
Median	1
Mode	1
Standard Deviation	**0,66868**
Sample Variance	0,44713
Kurtosis	-0,58890
Skewness	-0,03680
Range	2
Minimum	0
Maximum	2
Sum	31
Count	30

Question 9	
Mean	**2,07**
Standard Error	0,09509
Median	2
Mode	2
Standard Deviation	**0,52083**
Sample Variance	0,27126
Kurtosis	1,08897
Skewness	0,10925
Range	2
Minimum	1
Maximum	3
Sum	62
Count	30

Question 10	
Mean	**2,17**
Standard Error	0,08419
Median	2
Mode	2
Standard Deviation	**0,46113**
Sample Variance	0,21264
Kurtosis	1,13180
Skewness	0,66983
Range	2
Minimum	1
Maximum	3
Sum	65
Count	30

Question 11	
Mean	**1,03**
Standard Error	0,13116
Median	1
Mode	1
Standard Deviation	**0,71840**
Sample Variance	0,51609
Kurtosis	-0,95372
Skewness	-0,04960
Range	2
Minimum	0
Maximum	2
Sum	31
Count	30

APPENDIX D.2
Oyak Questionnaire Results (Residents)

Question 1	
Mean	**0,97**
Standard Error	0,139649
Median	1
Mode	1
Standard Deviation	**0,71489**
Sample Variance	0,585057
Kurtosis	0,353232
Skewness	0,552966
Range	3
Minimum	0
Maximum	3
Sum	29
Count	30

Question 2	
Mean	**0,87**
Standard Error	0,104313
Median	1
Mode	1
Standard Deviation	**0,571346**
Sample Variance	0,326437
Kurtosis	0,207513
Skewness	-0,028173
Range	2
Minimum	0
Maximum	2
Sum	26
Count	30

Question 3	
Mean	**1,77**
Standard Error	0,170754
Median	2
Mode	1
Standard Deviation	**0,735261**
Sample Variance	0,874713
Kurtosis	-1,018758
Skewness	-0,038939
Range	3
Minimum	0
Maximum	3
Sum	53
Count	30

Question 4	
Mean	**0,20**
Standard Error	0,111417
Median	0
Mode	0
Standard Deviation	**0,610257**
Sample Variance	0,372414
Kurtosis	15,85064
Skewness	3,784509
Range	3
Minimum	0
Maximum	3
Sum	6
Count	30

Question 5	
Mean	**1,43**
Standard Error	0,114303
Median	1
Mode	1
Standard Deviation	**0,626062**
Sample Variance	0,391954
Kurtosis	0,430742
Skewness	1,171699
Range	2
Minimum	1
Maximum	3
Sum	43
Count	30

Question 6	
Mean	**1,27**
Standard Error	0,106494
Median	1
Mode	1
Standard Deviation	**0,583292**
Sample Variance	0,34023
Kurtosis	3,746804
Skewness	2,147972
Range	2
Minimum	1
Maximum	3
Sum	38
Count	30

Question 7	
Mean	**0,87**
Standard Error	0,164235
Median	1
Mode	1
Standard Deviation	**0,699553**
Sample Variance	0,809195
Kurtosis	0,212653
Skewness	0,886082
Range	3
Minimum	0
Maximum	3
Sum	26
Count	30

Question 8	
Mean	**1,03**
Standard Error	0,216998
Median	1
Mode	0
Standard Deviation	**0,68855**
Sample Variance	1,412644
Kurtosis	-0,796266
Skewness	0,856033
Range	3
Minimum	0
Maximum	3
Sum	31
Count	30

Question 9	
Mean	**1,13**
Standard Error	0,079269
Median	1
Mode	1
Standard Deviation	**0,434172**
Sample Variance	0,188506
Kurtosis	12,5136
Skewness	3,494974
Range	2
Minimum	1
Maximum	3
Sum	34
Count	30

Question 10	
Mean	**1,80**
Standard Error	0,111417
Median	2
Mode	2
Standard Deviation	**0,610257**
Sample Variance	0,372414
Kurtosis	-0,298354
Skewness	0,117047
Range	2
Minimum	1
Maximum	3
Sum	54
Count	30

Question 11	
Mean	**0,90**
Standard Error	0,146609
Median	1
Mode	1
Standard Deviation	**0,703012**
Sample Variance	0,644828
Kurtosis	1,53211
Skewness	1,044578
Range	3
Minimum	0
Maximum	3
Sum	27
Count	30

APPENDIX D.3
Mavişehir Questionnaire Results (Residents)

Question 1	
Mean	**2,37**
Standard Error	0,122083
Median	2
Mode	3
Standard Deviation	**0,668675**
Sample Variance	0,447126
Kurtosis	-0,588899
Skewness	-0,586005
Range	2
Minimum	1
Maximum	3
Sum	71
Count	30

Question 2	
Mean	**2,30**
Standard Error	0,085096
Median	2
Mode	2
Standard Deviation	**0,466092**
Sample Variance	0,217241
Kurtosis	-1,242126
Skewness	0,9195
Range	1
Minimum	2
Maximum	3
Sum	69
Count	30

Question 3	
Mean	**2,13**
Standard Error	0,133333
Median	2
Mode	2
Standard Deviation	**0,730297**
Sample Variance	0,533333
Kurtosis	3,51447
Skewness	-1,352443
Range	3
Minimum	0
Maximum	3
Sum	64
Count	30

Question 4	
Mean	**2,77**
Standard Error	0,07854
Median	3
Mode	3
Standard Deviation	**0,430183**
Sample Variance	0,185057
Kurtosis	-0,25732
Skewness	-1,328338
Range	1
Minimum	2
Maximum	3
Sum	83
Count	30

Question 5	
Mean	**2,77**
Standard Error	0,07854
Median	3
Mode	3
Standard Deviation	**0,430183**
Sample Variance	0,185057
Kurtosis	-0,25732
Skewness	-1,328338
Range	1
Minimum	2
Maximum	3
Sum	83
Count	30

Question 6	
Mean	**2,50**
Standard Error	0,104497
Median	3
Mode	3
Standard Deviation	**0,572351**
Sample Variance	0,327586
Kurtosis	-0,619707
Skewness	-0,591151
Range	2
Minimum	1
Maximum	3
Sum	75
Count	30

Question 7	
Mean	**2,37**
Standard Error	0,089486
Median	2
Mode	2
Standard Deviation	**0,490133**
Sample Variance	0,24023
Kurtosis	-1,784005
Skewness	0,582933
Range	1
Minimum	2
Maximum	3
Sum	71
Count	30

Question 8	
Mean	**2,67**
Standard Error	0,099808
Median	3
Mode	3
Standard Deviation	**0,546672**
Sample Variance	0,298851
Kurtosis	1,201183
Skewness	-1,407115
Range	2
Minimum	1
Maximum	3
Sum	80
Count	30

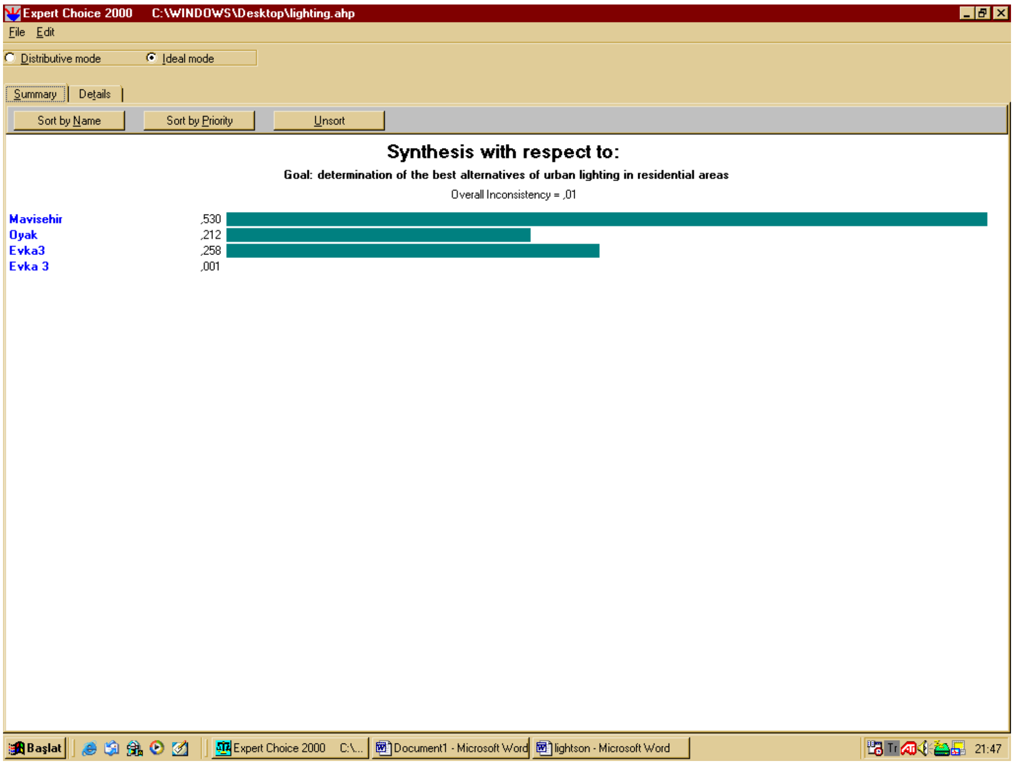
Question 9	
Mean	**2,27**
Standard Error	0,09509
Median	2
Mode	2
Standard Deviation	**0,52083**
Sample Variance	0,271264
Kurtosis	-0,294558
Skewness	0,297532
Range	2
Minimum	1
Maximum	3
Sum	68
Count	30

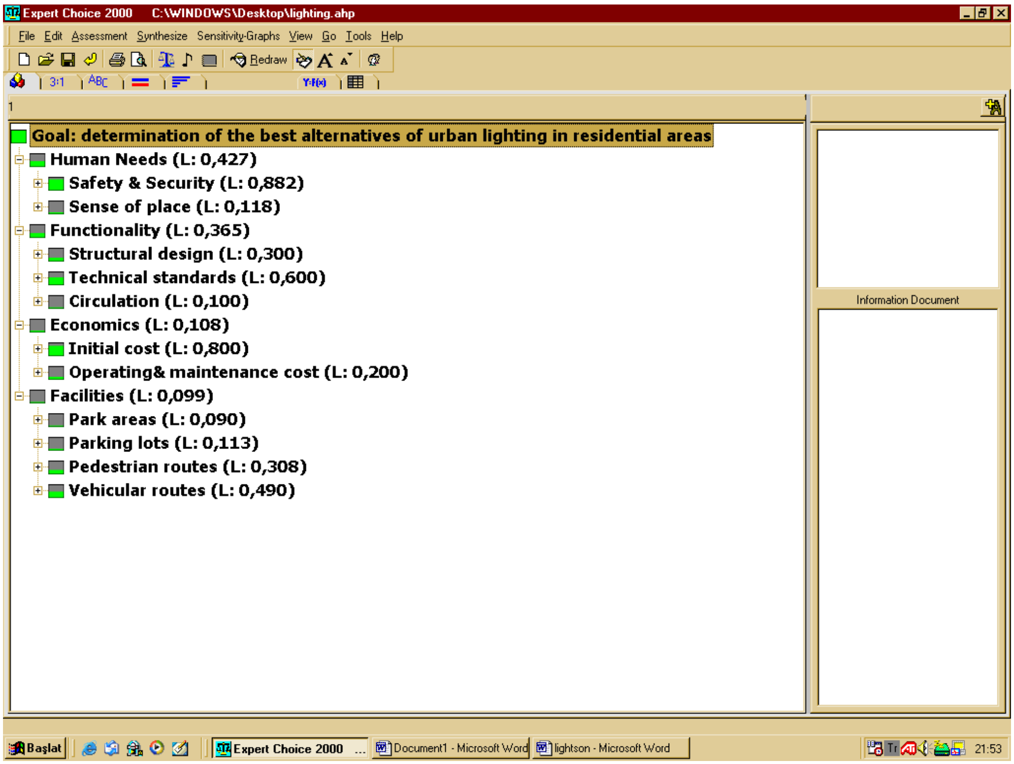
Question 10	
Mean	**2,90**
Standard Error	0,055709
Median	3
Mode	3
Standard Deviation	**0,305129**
Sample Variance	0,093103
Kurtosis	6,308054
Skewness	-2,80912
Range	1
Minimum	2
Maximum	3
Sum	87
Count	30

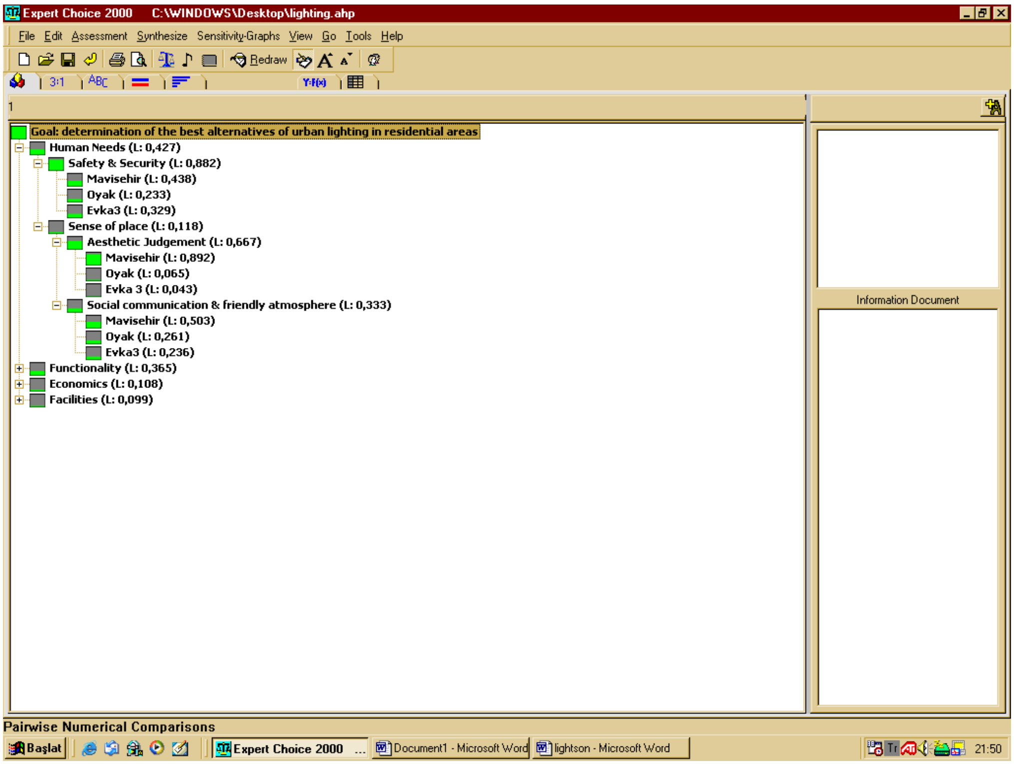
Question 11	
Mean	**2,73**
Standard Error	0,09509
Median	3
Mode	3
Standard Deviation	**0,52083**
Sample Variance	0,271264
Kurtosis	2,933681
Skewness	-1,866548
Range	2
Minimum	1
Maximum	3
Sum	82
Count	30

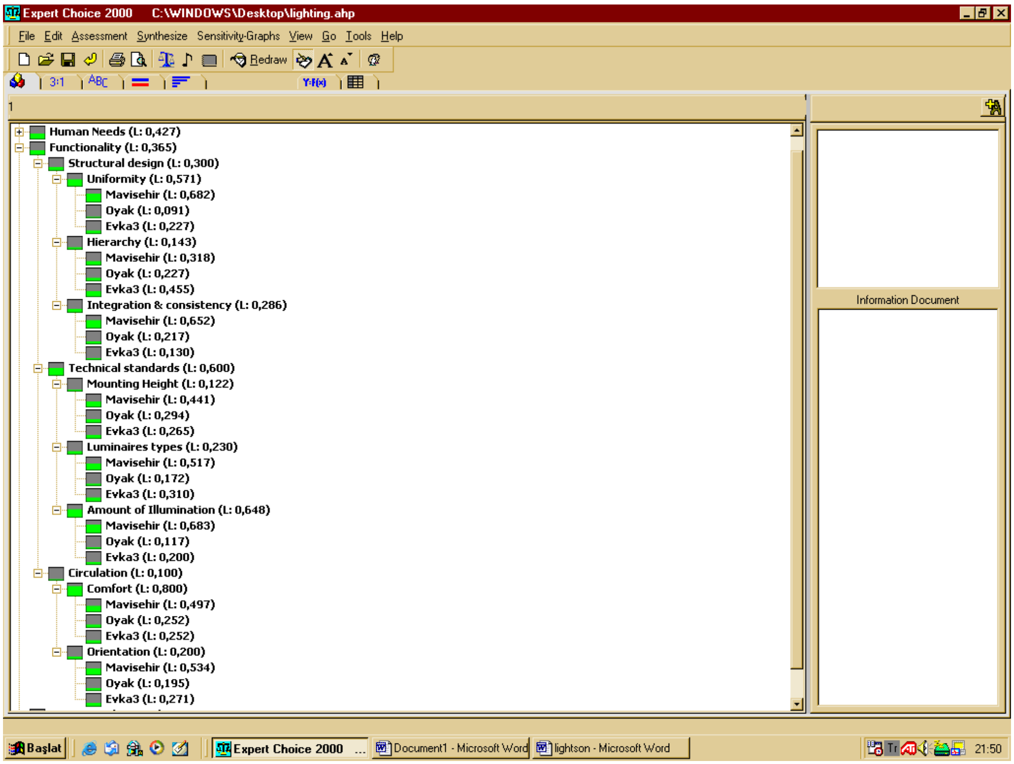
APPENDIX E
SCREENS FROM THE HIERARCHY MODEL AND ASSESSMENTS

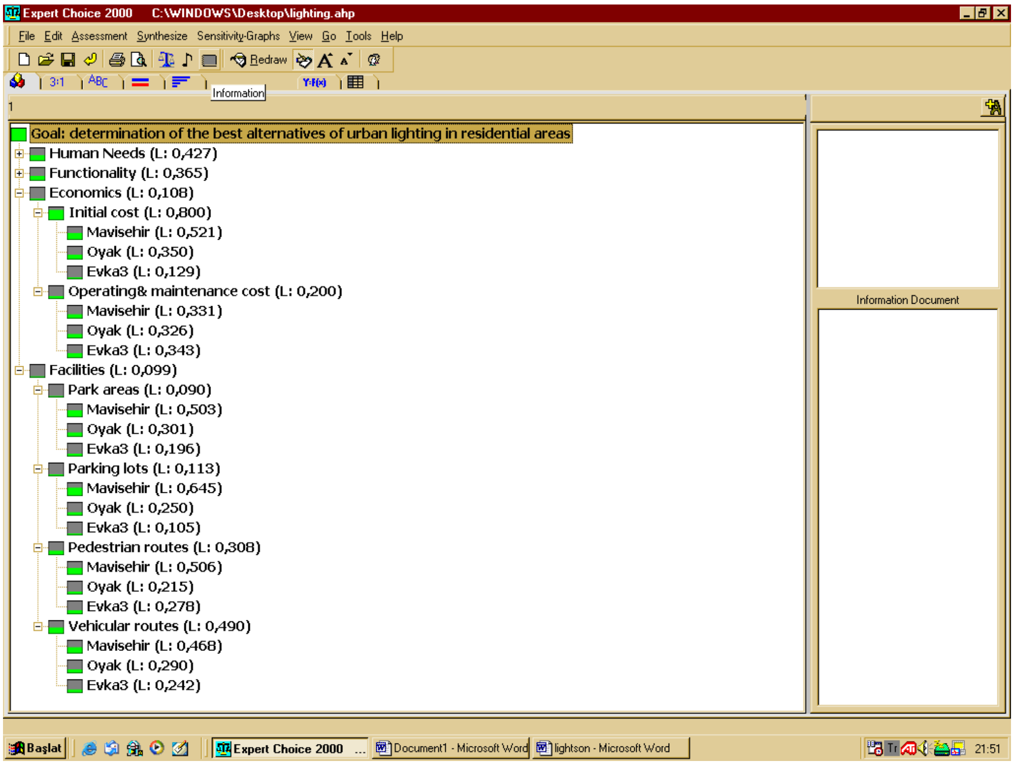
These screens are provided by Expert Choice Software Package.

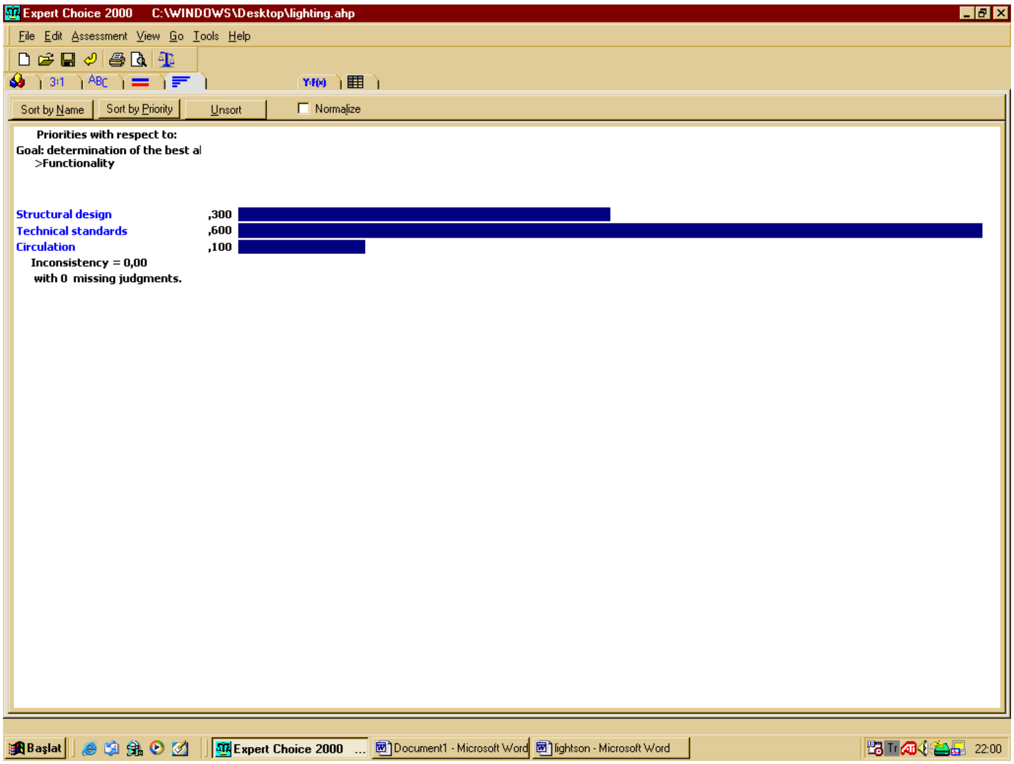





Expert Choice 2000 C:\WINDOWS\Desktop\lighting.ahp
File Edit Assessment Synthesize Sensitivity-Graphs View Go Tools Help
Redraw
Goal: determination of the best alternatives of urban lighting in residential areas
Human Needs (L: 0,427)
Safety & Security (L: 0,882)
Mavisehir (L: 0,438)
Oyak (L: 0,233)
Evka3 (L: 0,329)
Sense of place (L: 0,118)
Aesthetic Judgement (L: 0,667)
Mavisehir (L: 0,892)
Oyak (L: 0,065)
Evka 3 (L: 0,043)
Social communication & friendly atmosphere (L: 0,333)
Mavisehir (L: 0,503)
Oyak (L: 0,261)
Evka3 (L: 0,236)
Functionality (L: 0,365)
Economics (L: 0,108)
Facilities (L: 0,099)
Information Document
Pairwise Numerical Comparisons
Başlat
Expert Choice 2000
Document1 - Microsoft Word
lightson - Microsoft Word
21:50


Expert Choice 2000 C:\WINDOWS\Desktop\lighting.ahp
File Edit Assessment Synthesize Sensitivity-Graphs View Go Tools Help
Redraw
Human Needs (L: 0,427)
Functionality (L: 0,365)
Structural design (L: 0,300)
Uniformity (L: 0,571)
Mavisehir (L: 0,682)
Oyak (L: 0,091)
Evka3 (L: 0,227)
Hierarchy (L: 0,143)
Mavisehir (L: 0,318)
Oyak (L: 0,227)
Evka3 (L: 0,455)
Integration & consistency (L: 0,286)
Mavisehir (L: 0,652)
Oyak (L: 0,217)
Evka3 (L: 0,130)
Technical standards (L: 0,600)
Mounting Height (L: 0,122)
Mavisehir (L: 0,441)
Oyak (L: 0,294)
Evka3 (L: 0,265)
Luminaires types (L: 0,230)
Mavisehir (L: 0,517)
Oyak (L: 0,172)
Evka3 (L: 0,310)
Amount of Illumination (L: 0,648)
Mavisehir (L: 0,683)
Oyak (L: 0,117)
Evka3 (L: 0,200)
Circulation (L: 0,100)
Comfort (L: 0,800)
Mavisehir (L: 0,497)
Oyak (L: 0,252)
Evka3 (L: 0,252)
Orientation (L: 0,200)
Mavisehir (L: 0,534)
Oyak (L: 0,195)
Evka3 (L: 0,271)
Information Document
Başlat
Expert Choice 2000
Document1 - Microsoft Word
lightson - Microsoft Word
21:50


Expert Choice 2000 C:\WINDOWS\Desktop\lighting.ahp
File Edit Assessment Synthesize Sensitivity-Graphs View Go Tools Help
Redraw
Information
Goal: determination of the best alternatives of urban lighting in residential areas
Human Needs (L: 0,427)
Functionality (L: 0,365)
Economics (L: 0,108)
Initial cost (L: 0,800)
Mavisehir (L: 0,521)
Oyak (L: 0,350)
Evka3 (L: 0,129)
Operating& maintenance cost (L: 0,200)
Mavisehir (L: 0,331)
Oyak (L: 0,326)
Evka3 (L: 0,343)
Facilities (L: 0,099)
Park areas (L: 0,090)
Mavisehir (L: 0,503)
Oyak (L: 0,301)
Evka3 (L: 0,196)
Parking lots (L: 0,113)
Mavisehir (L: 0,645)
Oyak (L: 0,250)
Evka3 (L: 0,105)
Pedestrian routes (L: 0,308)
Mavisehir (L: 0,506)
Oyak (L: 0,215)
Evka3 (L: 0,278)
Vehicular routes (L: 0,490)
Mavisehir (L: 0,468)
Oyak (L: 0,290)
Evka3 (L: 0,242)
Information Document
Başlat
Expert Choice 2000
Document1 - Microsoft Word
lightson - Microsoft Word
21:51


Expert Choice 2000 C:\WINDOWS\Desktop\lighting.ahp
File Edit Assessment View Go Tools Help
Sort by Name
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Priorities with respect to:
Goal: determination of the best al
>Functionality
Structural design ,300
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Inconsistency = 0,00
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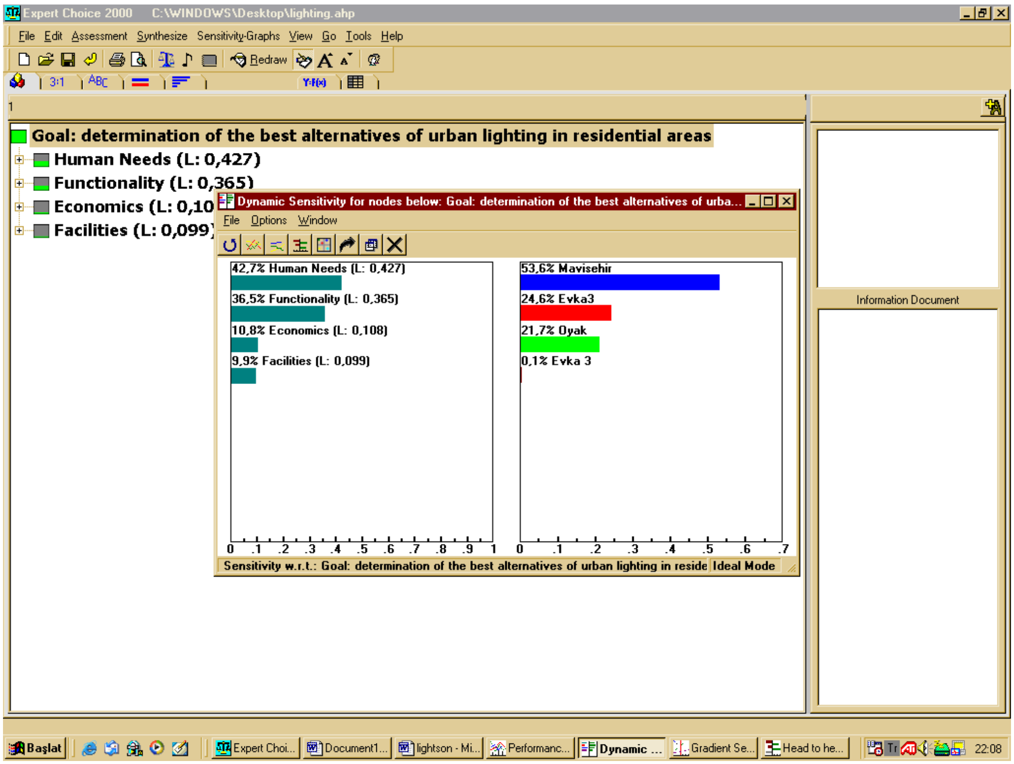
22:00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File Edit Assessment Synthesize Sensitivity-Graphs View Go Tools Help
Redraw
Goal: determination of the best alternatives of urban lighting in residential areas
Human Needs (L: 0,427)
Functionality (L: 0,365)
Economics (L: 0,10
Facilities (L: 0,099)
Dynamic Sensitivity for nodes below: Goal: determination of the best alternatives of urba...
File Options Window
42,7% Human Needs (L: 0,427)
36,5% Functionality (L: 0,365)
10,8% Economics (L: 0,108)
9,9% Facilities (L: 0,099)
53,6% Mavisehir
24,6% Evka3
21,7% Oyak
0,1% Evka 3
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1
0 .1 .2 .3 .4 .5 .6 .7
Sensitivity w.r.t.: Goal: determination of the best alternatives of urban lighting in reside
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Information Document
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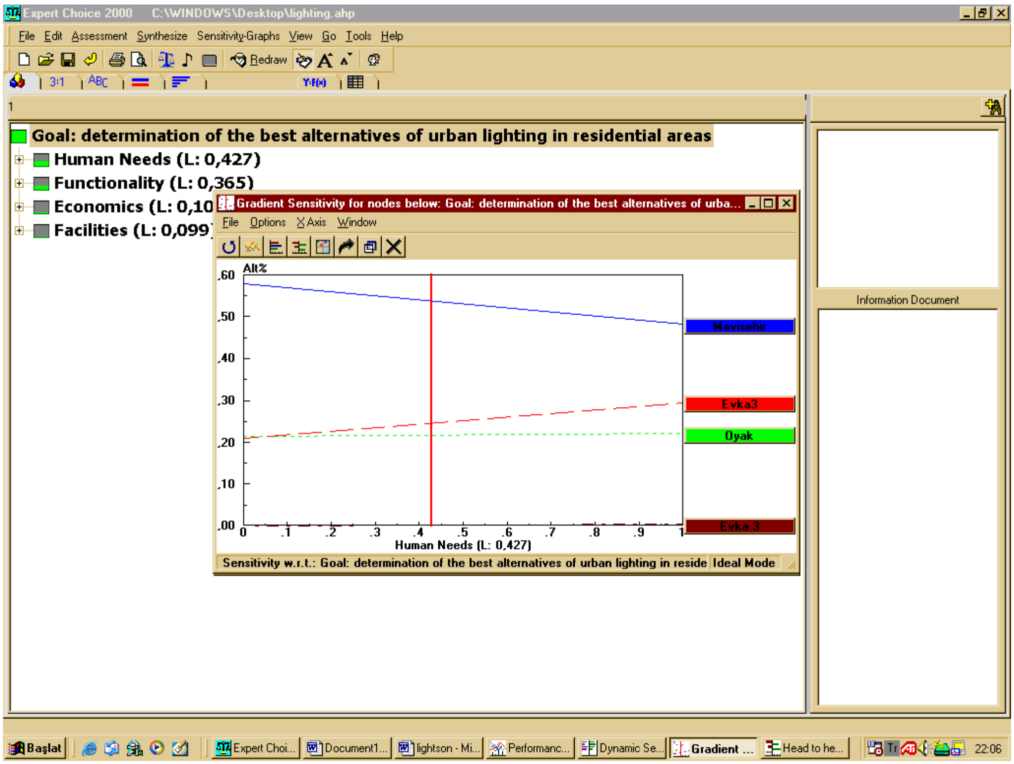
22:08


Expert Choice 2000 C:\WINDOWS\Desktop\lighting.ahp
File Edit Assessment Synthesize Sensitivity-Graphs View Go Tools Help
Redraw
Goal: determination of the best alternatives of urban lighting in residential areas
Human Needs (L: 0,427)
Functionality (L: 0,365)
Economics (L: 0,10
Facilities (L: 0,099)
Gradient Sensitivity for nodes below: Goal: determination of the best alternatives of urba...
File Options X Axis Window
Alt%
,60
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,20
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Mavisehir
Evka3
Oyak
Evka 3
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1
Human Needs (L: 0,427)
Sensitivity w.r.t.: Goal: determination of the best alternatives of urban lighting in reside
Ideal Mode
Information Document
Başlat
Expert Choi...
Document1...
lighton - Mi...
Performanc...
Dynamic Se...
Gradient ...
Head to he...
22:06