“Day for Night”
The Role of Artificial Lighting in Returning People to Urban Public Spaces

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ABSTRACT

In many cultures the word “night”, as it bears a meaning of “darkness” has been used negatively. All through the history the fear of mankind from darkness, as the world of unknown treats, still exists in the memory of the city dwellers. This study is concerned with the evolution of lighting design in public spaces. Although some researchers have devoted attention to outdoor lighting, they have devoted little attention to lighting as an urban design parameter. The purpose of this research is to understand how planning, developing and revitalizing of appropriate lighting design for urban space supports bringing people back to the public spaces of the city. Literature review revealed that for bringing back people to the city, not only a comprehensive lighting design, but also various factors to ensure the durability of public use has to be considered. Current dissertation pointed out; in order to be able to attract people to urban public spaces, set of rules and guidelines has to be applied to the lighting of public spaces which calls Lighting Master Plan. 13 factors divided into 3 categories have been suggested as the framework for evaluating lighting condition of a city or a region within the city. In conclusion, lighting conditions of the case study (Walled-City in Famagusta) have been evaluated, considering mentioned factors and solutions, and suggested for enhancement of public lighting in this region.

Keywords: Public space, Lighting design, Lighting Master Plan

ÖZ

Birçok kültürde gece kelimesi, karanlık anlamı taşıdığından olumsız kullanılmıştır. Tarih boyunca insanlar karanlıktan korkmuştur. Bu çalısma, aydınlatma tasarımını kentsel alanlarındaki gelişimini içerir. Bazı araştırmalar dış aydınlatmaya dikkat etmiş olmasına rağmen, bir kentsel tasarım parametresi olarak aydınlatmaya daha az dikkat etmişlerdir. Bu araştırmanın amacı kentsel mekana nasıl uygun aydınlatma tasarımı, planlaması, geliştirmesi ve canlandırmasını anlatır ve kentin kamusal alanlara insanları geri getirmek icin destekler. Önceki araştırmalarda çeşitli faktörlerin tam bir aydınlatma tasarımı için gerekli olduğunu göstermektedir. Mevcut tez, insanları kentsel kamusal alanlara çekmek için bir "Aydınlatma Master Planı" adı altında; bu kamusal mekanları aydınlatmak için bir kurallar kümesi ve yönergeleri uygulanmıştır. 13 faktör kentsel aydınlatma mekanlarını değerlendirmek için bir çerçeve öne sürmüştür. Sonuç olarak, G.Mağusa Suriçi aydınlatmaya koşulları dikkate alınarak belirtilen faktörler değerlendirilmiştir.

Anahtar Kelimeler: Kamusal alan, aydınlatma tasarımı, aydınlatma master planı

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INTRODUCTION

1.1 Definition of Problem

Social interaction is becoming one of the main concerns of recent decades. A wide range of internet usage and computer based activities take the chance from people to meet and socialize in public spaces. Therefore, enhancement of public spaces is becoming more important, in order to create reasonable places for social activities. Since most people have free time at night, lighting plays a key role in the improvement of the quality of an urban public space during the night. This study aims to find effective factors in bringing people back to the public urban spaces during the night, and examine the role of artificial lighting related to this issue. Furthermore, this study seeks to formalize and define a common ground for analyzing lighting in the urban scale.

Darkness has been a symbol of negative concepts in many cultures, although the reasons may change, the result is still same; people do not like to be in a dark or in a low lit place. Since working hours are mostly during the day, in the modern world night brings free time for contemporary life styles. Here the contrast appears whereby free time gives people a chance to socialize in public spaces, while the negative concept of being in a dark place creates a hidden barrier for people to avoid urban public spaces during the night. Since we already have public spaces in most

cities, the problem is that these places work only during the day unless it has been well illuminated during the night as well.

Previous studies highlight a need for considering people's opinion on lighting design, although researchers have devoted much attention to the expectations regarding both public spaces and lighting. They have devoted little attention to feasibility of providing a comprehensive lighting in public urban spaces. Although studies have discussed the quality of public spaces and the quality of lighting separately, few have actually focused on the analysis of the role of artificial lighting in bringing people back to urban public spaces. The overall aim of this study, therefore, is to increase understanding of how we can provide a framework for evaluation of lighting in public urban spaces.

Questions this research seeks to answer are listed below;

-How can a comprehensive lighting design be applied to a region?

-How lighting can improve an urban public space with regard to new technologies and improvements in lighting industry?

-What are possible effects of light on human health and behavior?

-What are variables of a good lighting design?

1.2 Methodology

This research is based on a qualitative approach. It has involved a multi-method strategy as described below;

1- The study started with deskwork method and library research to find the improvement trend of light and lighting design through the time, continued by surveying about the effects of light on human being in terms of health and behavior.

2- After finding main expectations related with features and requirements in the field of lighting design and defining the state of art in lighting industries, study integrates two theories in the field of urban design and lighting design; 'City Image' by 'Kevin Lynch' and 'Lighting Design Principles' by 'Richard Kelly'. Followed by field work analysis of examination of three dominant examples which had applied Lighting Master Plan; 'Lyon','Stuttgart' and 'Vancouver'.

3- Afterward lighting design in the case study of "Walled City of Famagusta" has been investigated considering variables provided by literature review and analysis of two formerly mentioned examples.

4- In conclusion solutions has been suggested to eliminate or resolve problems pointed out from lighting analysis of the existing lighting situation of "Walled City of Famagusta"

Chapter 2

BREIF HISTORY OF LIGHTING

2.1 Introduction

"In the beginning it was dark and cold. There was no sun, no light, no earth, no solar system. There was nothing, just the empty void of space."(Williams 1999) The value and necessity of natural light for the evolution of life on the earth has been determined by scientific researches. But natural light was not controllable, neither adjustable, so human kind started to illuminate his environment with an alternative method for the times where natursl light was not available; ‘Artificial light’. In this chapter a survey of the evolution of artificial light thru the history is provided. Surveying the history of lighting gives us the chance to achieve a better understanding of solutions mankind had found to encounter the above mentioned barriers. Also, following the trend of improvements in lighting history gives clues about possible upcoming developments in the lighting industry which can play an important role in success of a lighting design.

2.2 Emerge of Artificial Light

Plant behavior conforms to the natural day-night cycle by starting their biological activities in sunrise and sleeping during the night; but there are also other creatures, that are not strictly determined by the natural day-night cycle in order to be able to defeat their enemies and survive. Some animals such as snakes, via infra-red sensors, and bats by echolocation (navigation by sending and receiving sound waves), are able to get information about their surrounding environment.(Fure, 2006) Since

mankind’s perception of surrounding has been mostly based on observation of visible range lights, therefore he/she started to use artificial lights to be able to secure himself from upcoming threats" during it’s natural absence. Clearly man must have been using fire to provide the necessary light to create his art, as many painting have been found deep within caves, far beyond the reach of daylight.” (28,000 BC-Lascaux, France) Early man was using primitive lamps made of natural materials like shells and stones with vegetable or animal fats as fuel. And this was the start of a progressive process of science and engineering of man-made light called ‘artificial lighting’. (Van santen, 2006)

2.3 Animal Lamps

Thousands of years earlier (5000 BC), animals were used as lamps by threading a wick into the body of oily birds and fishes. There are also records of using fireflies to provide light in Japan and India. (Williams 1999) Fuel lamps were also used during these ages but more likely by wealthy families. Olive oil was the main fuel used by Mediterranean countries, sesame (mainly in East), nut, fish, castor and plant oils were also common used oils for ancient lamps.

Natural lamps got more popular when the price decreased by 600BC with the Greek production of pottery lamps. “During the 6th, 5th and 4th centuries BC, Athens was a major manufacturer and exporter of high quality pottery lamps.” (Van Santen 2006). Gradually lamps got completely enclosed in form and also functioned as a medium for artistic expressions by Roman, Egyptian and early Greek between 500BC and 100 AD.

2.4 Portable Lamps and The First Illuminated Street

From the first century A.D there are remains of lamps which can be considered as portable light sources, like the horn lantern, which was a safe and suitable form for moving around within indoor spaces or even outdoors. Later, the candle was invented in about 400 A.D. “The best candles were made of beeswax and were used chiefly in church rituals because the bee was regarded as a symbol of purity.” (Williams 1999). Common people were not able to buy beeswax candles because they were expensive; they used crude tallow candles instead, which was smelly and smoky.

“In world history, the first street to be illuminated regularly at night was Herod Street in Antakya in 2nd century AD”. Most probably oil lamps were used to illuminate Herod Street however, author did not find any official records to claim which light sources were actually used. Current name of Herod Street is; ‘Kurtuluş Street’ located in Hatay-Turkey.(Diplomaticobserver 2008)

2.5 The Medieval Period, Renaissance and Later

During the medieval period there are not many records about the improvement of light and lighting until the 16th century. In the 16th century Sebastiano Serlio, an Italian painter and architect, developed color filters to be used in theatre stage lighting. “By using a brightly polished barber's basin behind a torch or candle, he developed an elementary spotlight, with a round bottle serving as the lens.” (Williams 1999). In one of Shakespeare’s plays in the 16th century, there were persons assigned to take care of the flame of the candles during the play. They had to trim wicks to keep the scene clear from the smoke produced by candles. Theater, which was a popular art dealing with an audience of various sizes (compared with

painting or poetry), helped improve the concept of lighting in public spaces. Stage lighting began during Renaissance Italy using chandeliers, as theaters increasingly moved to indoors, Later, oil float lamps were employed for illuminating the stage's front edge. In addition, "Candles behind the proscenium were used to light the scenery". (Williams, 1999)

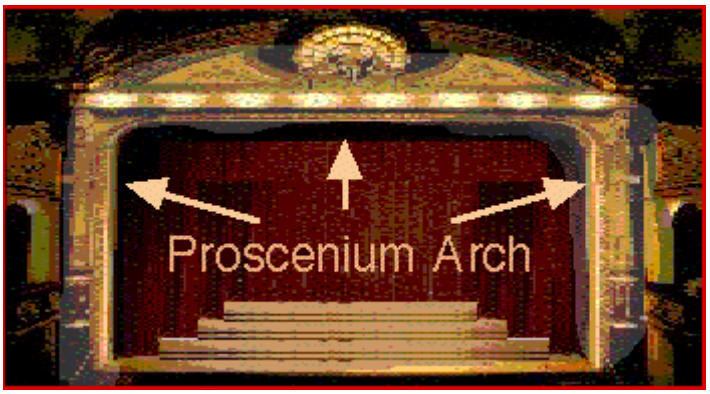


Figure 1: Candles were put behind proscenium arches in 16th century

Important permanent theaters in history are Teatro Olimpico and Teatro Farnese that were constructed in the 16th and 17th century respectively. The first theatre which had an open auditorium was designed by Andrea Palladio in Vicenza and is still in use. The second one which was built in Parma, was actually the first example of a theatre with stage curtain and proscenium by today's definition.

During the same period with Shakespeare in the 16th century, an artist and stage designer, Angelo Ingegneri (1550-1613), called lighting one of the main roles of an ultimate play. He was also a supporter of the concept of the 'obscured auditorium' during performances. At the coronation of George III, in 1761, "3000 candles were connected together with threads of gun cotton, and lit in half a minute." (Williams 1999) These light festivals were examples of how people were interested in using light , and how they were trying to improve the usage of lighting.

2.6 Gas Lamps (18th and 19th centuries)

In 1792 'William Murdock', in England, heated coal and produced light by using the gas to light his office and his home, and he called himself the father of gas lighting. "In 1804 Frederick Albert Windsor, a German entrepreneur, demonstrated and lectured on gas light at the Lyceum Theatre in London. His main interest in gas was for street lighting." (Williams 1999)

In the 19th century gas lighting developed enormously. In England, in 1823, 215 miles of London streets had been illuminated with 40,000 gas lamps. It was also used in theatre lighting, and the system had a centralized remote control system. In 1816 gas lighting was introduced to America, but mostly after 1850 gas lighting became common lighting for theatres. "Although gas had many advantages over oil lamps and candles, it is said that several hundred theatres burned down in Europe and America from the use of gas lighting." (Williams 1999).

While England's theatres were being lightened by gas lamps, 'Sir Humphrey Davy' was working on the development of electric carbon arc lights, which he had already demonstrated at the Royal Institution of Science in London. However France was first to use gas lamps in Paris Opera House, designed by 'Garnier' (1875).

2.7 Electric Lighting

2.7.1 Electric Arc Lamps and Carbon Arc Lamps

Electric arc lamps consist of two electrodes which are separated by gas and produces light by an electric arc. Carbon arc lamps also work with the same components except electrodes are carbon rods in free air. Electric arc lamps and Carbon arc lamps had life span around 100 hours .In 1877 Electric arc lamps were introduced outside

the Paris Opera House and the technology developed on a greater scale in America; “By 1884 there were 90,000 electric arc lamps burning by night in the USA”. Although High Intensity Discharge lamps are being used today for film projectors and followspots, the principal of the electric arc is still the same.(Williams 1999)

2.7.2 Central Electrical Station and the Invention of Bulb Lamps

In 1747 “Benjamin Franklin” supported the hypothesis of considering light as an electrical phenomenon. “His research into the nature of electricity helped pave the way for its practical use and resulted in the development of the lightning rod.” (Williams 1999). In 1874, five years before “Edison” turned the electric filament lamps into practical form, incandescent lamps were invented by “Henry Hoodward” and “Mathew Evans”, but the truth is that Edison was the one who successfully marketed incandescent lamps and electric lighting in 1879 through his company; the Edison Electric Light Company. The extension of night life is because Edison not only invented the light bulb but also constructed the electricity distribution system which distributed electricity supply made from the central generators. Pearl Street station was the first electrical power distributer which provided electricity for 59 customers in lower Manhattan. “In 1881, two years after the first incandescent lamp left Edison's workshop, the steamship 'Columbia' was fitted with a thousand of them. Within another two years, there were over 300 electric power stations in existence, feeding over 70,000 incandescent lamps, each with an average life of 100 hours.”(Van santen 2006)

At the same time that Edison was working on incandescent lamp, “Charles Summer Tainter”, in America, constructed the first photocells by using selenium cells to convert sunlight into electrical energy. “Alexander Graham Bell” was also using sunlight to create his ‘Photophone’ (1880) to transfer voice by wires. Although

‘photophone’ was not a success Graham Bell improved his product by using electricity and invented the ‘Telephone’ which was a great success.

In 1881 the first public building lighted entirely by electricity was opened; the Savoy Theatre in London. “Inventor, “Ward Leonard” worked with Edison to introduce the central station electrical system concept to cities in America. Leonard in 1892 received a patent for an electric elevator.”(Williams 1999). Neon was discovered in 1898 and in 1910 the first neon lamps were made in France by the engineer and inventor ‘Georges Claude (1870-1960), which were mostly (and are still) used for neon signs. Later the development of electric lighting led to the invention of High density discharge (HID) lamps, Mercury- vapor lamps, gas filled lamps, Tungsten filament lamps(instead of carbonized paper or cotton thread) and fluorescent lamps.

2.8 Laser

“The 'laser' - or - (light amplification by stimulated emission of radiation) was perfected in 1960, by research scientist Theodore Maiman at the Hughes Laboratory in Malibu California.” But before Maiman, Gordon Gould at University of Coloumbia had discovered the concept. But, the Defense Department of United State classified his patent as secret because of its potential to become a “death-ray”. “Physicists Charles H. Townes and his brother-in-law Arthur Schawlow were the first to actually apply for a patent on the laser and they were the first to publish their findings in scientific journals in 1953.”(Khodadad 2003)

From the first commercial use of laser in 1968, up to now, there exists a wide range of functions such as for cutting materials, determining distances, projecting 3-dimentional holographic images, printing, surgery and entertainment lighting

applications. “Laser light differs from ordinary light in four ways. Briefly it is much more intense, directional, monochromatic and coherent. Most lasers consist of a column of active material with a partly reflecting mirror at one end and a fully reflecting mirror at the other. In a typical solid laser material, a ruby crystal, the active ingredients are chromium atoms interspersed in the crystal lattice of aluminum oxide. The laser is primed by pumping these atoms, by means of a flash of intense light, to an excited state. This causes the system to produce a cascade of photons, all of the same wavelength and all in step with each other.”(Williams 1999) Holography is also a technic for creating three-dimensional images based on laser technology. Due to the modality of laser light, it is not a proper source and have never been used for illumination purposes in public spaces, unless for temporary artistic installations or entertainment activities.

Figure 2: Laser lights

2.9 Light Emitting Diodes (LEDs)

Previously, Low-Pressure Sodium Lamps were extensively used for Urban Lighting, due to the high lamp efficacy and lamp life. “However, due to the low color

rendering abilities of these lamps, the resultant nightscapes were rendered in a greyish hue and the original vibrant colors were subdued in the night."(Theresa L. Shanahan, 2000) But recent development resulted in greater efficiency of Metal Halide Lamps and introduction of new lamps, like LEDs (Light Emitting Diodes) and OLEDs (organic light-emitting diodes) are both solid-state lighting components which convert electricity into light by semiconductors instead of filament or gas. LEDs have been used for more than 50 years in electronic devices and later as indicators such as traffic signs. Primary LEDs were only available in red color. However, in recent decades the improvements in this light source made these lamps available in a wide range of colors, such as white, which makes it compatible with diverse applications. Due to the low energy consumption of LEDs they are also the most compatible available light source with solar based technology, compared with other low energy consumers, such as compact fluorescent lamps. The latter makes it a considerable light source for conditions where electricity is not available because of the lack of electricity info-structures. Research by R. Pode (2009) on the enhancement of solar powered LED concludes that solar based LED lanterns can provide affordable light for 1.6 billion people in Asia and Africa who don't have access to electricity and currently use fuel based lanterns. "Replacing kerosene with LED lights offers benefits such as; reduced air pollution, improved studying conditions for children, and reduced spending by poor families up to 70%."(R. pode 2009)

Figure 3: Two examples of rechargeable LED lanterns

The Rensselear Lighting Research Center points out the following factors in comparing LEDs with former light sources such as incandescent and florescent lamps;

Long life — LEDs can provide 50,000 hours or more of life, which can reduce maintenance costs. In comparison, an incandescent light bulb lasts approximately 1,000 hours.

Energy savings — The best commercial white LED lighting systems provide three times the luminous efficacy (lumens per watt) of incandescent lighting. Colored LEDs are especially advantageous for colored lighting applications because filters are not needed.

Better quality light output — LEDs have minimum ultraviolet and infrared radiations which can cause health disorders.

Intrinsically safe — LED systems are low voltage and generally cool to the the touch.

Smaller, flexible light fixtures — The small size of LEDs makes them useful for lighting tight spaces and for creating unique applications.

Durable — LEDs have no filament to break and can withstand vibrations. (Solid State Lighting, 2011)

As the research shows LEDs, as the latest invention in lighting industry, are widely accepted as the new generation of light sources in such fields as architecture lighting, urban lighting and advertisements. Some examples of LED based lightings can be seen in chapter four and five of current research.

2.10 Conclusion

An overview on the history of light shows how mankind's effort to illuminate his environment led to improvement of lighting industry. Although the amounts of light have been increased in indoor and outdoor spaces by these improvements, it seems that the concept is still the same but with new technologies. Interior and exterior spaces, public events and theatre stages had been lit by oil lamps and candles before and are being lit with fluorescent and led lamps now. In other words the history shows man has had the ability to illuminate public outdoor spaces with candles since 16^{th} century so an illuminated public space is not a new phenomenon. But the main differences between outdoor lighting in second decade of 21^{st} century and 16^{th} century are first to be relieved of time boundaries by high efficiency light sources that consume much less energy than before. The second difference is the great improvement of lighting equipment which leads to better quality of lighting.

Also it can be stated that it seems like whenever architecture conquers a barrier and removes a boundary, architects celebrate it with extreme designs which create unique

architectural character of the time. For instance Gothic architecture celebrated overcoming the barriers of thick walls (bearing walls). The result was spaces, extremely filled with color and light by means of sunlight through stained glass windows. The Modern architecture celebrated mass production as a solution to fulfill the huge demand of housing after two destructive wars. The investigation of light trough the history shows the great effort human kind have made to overcome the "darkness" and to remove the division between day and night by bringing timeless light to the city. The 21st century seems to be extending the possibilities for designers, for overcoming the barriers of darkness in terms of lighting in outdoor spaces by means of using solar energy and production of high efficiency light sources.

In conclusion the history of lighting reminds us that providing visibility is not the main anticipation of people from lighting of an urban public space of 21st century, but the quality and the functions and atmosphere it facilitates as well as the meaning it gives to a specific space are the main issues that can absorb people to the urban public spaces of today's cities.

Chapter 3

HUMAN FACTORS IN LIGHTING (VISUAL AND NON-VISUAL EFFECTS OF LIGHT)

3.1 Introduction

The history of lighting showed humankind is always in an effort to modify the environment in order to increase comfort by means of improving living circumstances. Light is one of the main tools people use to improve their night life. Since people, intentionally or unintentionally, are under exposure of artificial light, visual and nonvisual effects of light is an important issue to be considered in lighting design. Mostly public are not aware of psychological and physiological effects of light so there may not be many records of complains about lighting circumstances of a public space, but considering these factors in a lighting design is so important to ensure both public health and durability of a lighting design. including uncontrolled growth of outdoor lighting will lead to overloaded lit urban spaces which can cause serious health problems. In current chapter the study seeks to examine the influences light may have on human body or surrounding environment and the study seeks to find possible affections of this phenomenon by analyzing both visual and non-visual effects of lighting and light sources on people.

Below general characteristics of light and solutions in which, fulfills visual comfort for people is surveyed, followed by qualitative aspects of lighting in a space considering Richard Kelly's (1910 – 1977) principles for lighting design.

3.2 User's Comfort – Primary Expectations

3.2.1 Visibility

Providing visibility is the most prominent role of lighting which makes it an essential part of people's daily life. Visibility of objects depends on the reflection of the light from different surfaces. Clearly light paving stones or a brightly colored road surface reflects more light than dark paving stones or dark asphalt. The visibility of objects depends directly on the amount of reflected light from the objects which ensures safety and orientation. People mostly consider this as enough light.

3.2.2 Glare and Sparkle

Glare is not pleasant in anyway. High amount of glares can even cause temporary blindness. "The brightness of the light must be limited or shielded in (almost) horizontal directions" (Van Santen 2006). The best result is obtained when the light source is not visible and reflections from high reflective surfaces are not in (or close to) eye level. (Figure 4).

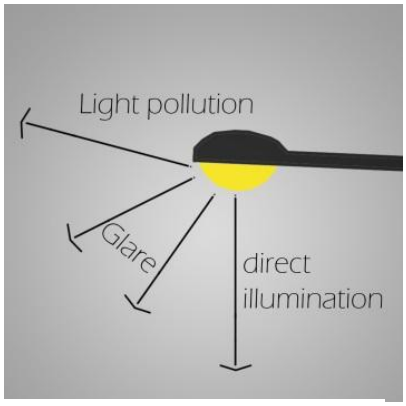


Figure 4: Glare and Light pollution caused by a street light

"Excessive contrast or illuminance is distracting and annoying. This negative side of luminance is called *glare*."(Gordon & Nuckolls 1995).When bright light sources, like light bulbs or reflection of light from a high reflective surface is exposed to the field of view, glare occurs. Gordon divides glare into "direct glare" and "reflected glare" (1995). The first type occurs when an unshielded light source is visible, therefore the uncontrolled luminance of bare light source meets the eye, while the reflected glare can be caused by the reflection of light from a polished or high reflective surface. Glare can be an annoying discomfort for visibility, and cause pain or even temporary

blindness, depending on intensity and angle of obtrusive light. For old people, due to the aging characteristics of eye, glare may hurt more. Indirect illumination, as a solution for glare prevention, has become more and more common in recent years. A common model is a mounted surface, faced to the ground that reflects and diffuses the light. This model is mostly used where a diffused light is needed rather than specific spots, like green areas, parks, beside boulevards and alongside water. (Van Santen 2006)

If the size of light source gets reduced, while still emitting high intense light, sparkle appears. Sparkles can arouse excitement and visual interest, however uncontrolled amount of sparkle may again cause glare. A good example of sparkle is the way street lights appear in the distance from the city. However, inside the city, usage of sparkling light should be restricted near roads and highways because it may be dangerous for drivers, due to the fact that it disturbs the eye strongly.

3.2.3 Color Rendering and Relative Position of Lighting

A high range of color rendering shows the closeness of the artificial light to the natural sunlight. By declination of color rendering eyes will not be able to render the colors properly which means a specific color or a range of colors will appear in a different color rather than the way it looks in natural light. ” Doing justice to colors plays a role in social interaction. The color of clothing, for example, must be clearly identifiable in pedestrian areas. From security point of view, the recognition of colors is also important, for example, in witness statements to the police.” (Van Santen 2006). The correct height of the luminaire and the distances between them is also a critical factor which leads to continuity of vision. The ‘cones’ of lights must overlap with each other in order to guarantee continuous vision. These two factors together

give us the ability to create three-dimensional shapes, which is needed for the recognition of people and objects.

3.2.4 Light Trespass

Light trespass is light being cast where it is not wanted or needed; such as light from a streetlight or a floodlight that illuminates a residential unit making it uncomfortable for the indoor use. Light trespass is a subjective aspect since it is not easily defined when, where, and how much light is unwanted. However the most common example of light trespass is the light entering the residential dwellings from road lighting, sports lighting or floodlighting of buildings. (A. Unver 2009)

Solutions to prevent light trespass depend on specific situations. Such variables as well shielded light sources, well oriented light bulbs (downward or upward with reflector), low intensity sources for upward lights and specially, accurate and downward angled position for advertisement displays, may help to overcome the light trespass problem.

3.2.5Light Pollution

Rapid development of light sources is improving lighting systems, yet in some cases brings excess amount of light that may cause light pollution. Inappropriate direction of light source, unsuitable shielding of lighting fixtures or the quantity and size of lighting elements may cause undesired effects of artificial urban lighting for human being and for the plants and animals as well(van Santen 2006). Two aspects of light pollution is reviewed in this research; sky glow, and visual pollution. ‘Glare’ and ‘Light Trespass’ effects which have been discussed before in this research (3.1.2 and 3.1.4) can also be categorized as other aspects of light pollution.

3.2.6 Sky Glow

Sky glow decreases the contrast of light and darkness of sky at night, therefore, changes the natural view of sky at night. Excessive and uncontrolled brightness emitted upward by luminaires or reflected skyward from surfaces. “The sky glow is generally considered as a concern for the astronomers because it reduces their ability to view celestial objects. Sky glow increases the brightness of the dark areas of the sky, which reduces the contrast of stars or other celestial objects against the dark sky background.”(A. Unver 2009) Using downwards directed lights in architectural lighting and street lighting, and avoiding disproportionate angling of lighting equipment are simple solutions to decrease sky glow. In conditions, in which, upward light is needed, light flow should be carefully targeted to minimize the loss of light (A. Unver 2009), (VanSanten 2006) (Fig 5).

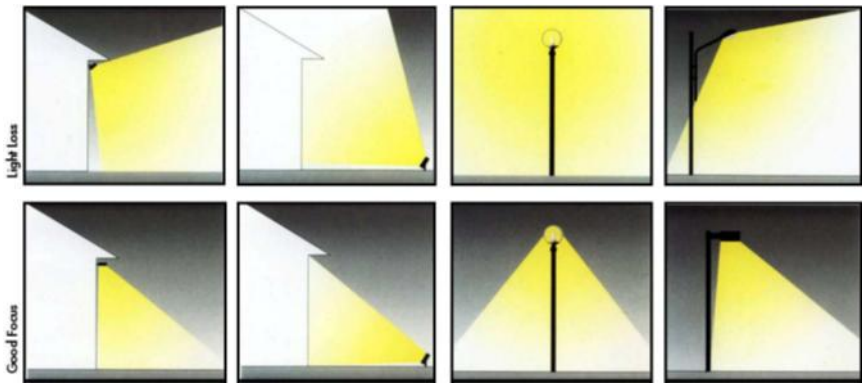


Figure 5: Light Loss and Good Focus source: Crista Van Santen 2006

3.2.7 Visual Pollution

Light brought us life, beauty and the colorful world of fantasy. Without light level differences, none of us would be able to create a beautiful imagination of our own. This fascination to light and color is exactly what advertisement takes advantages of. Colorful billboards with high intensity lights on them, then colorful neon signs in the

mid 80's when, light itself became a medium to transfer a message instead of illuminating the message, and nowadays big digital screens give the commercial message as well as changing the whole environment each ten seconds, by changes in moods of light and color. This might be "fun" or "amusing" at first, but when it comes to the point that it grow like mushroom and penetrate to the whole face of the city the result will sure be a chaos. Since the industry of advertisement pumps the eager to the city dweller's brains, telling them what to buy, who to trust and even how to think, and it is an ongoing business and will be, since powers of times will need them, so it seems logical to see complete replacement of current billboards with big LED screens. (like what happened in Shanghai or Tokyo). Here the role of lighting technology and lighting designers gets more and more important. In other words architects form the daytime face of the city, while lighting designers are creating the different world of "night life". These two sides of city's face are getting more and more separate. To some extent we may need new rules, more concerned with lighting to prevent the chaos and keep the visual unity of a city during the night, rather than common restrictions for the height of the building or the percentage of land usage. (K. Talebian, 2012)

3.3 Light and Public Health

There are no records for some of light sources such as incandescent lamps to be harmful for human body, but there are also light sources which can be harmful for user's health such as florescent lamps, Compact Florescent Lamps (CFLs), high pressure sodium lamps and LEDs.(Fabio Falchi, 2011)

3.3.1 Mercury Based Lamps

Mercury based lamps got widely popular in late 90's due to their efficiency comparing with incandescent lamps. Since Inhaling mercury or mercury mixtures as vapor or in powder form can cause serious health problems all kinds of light sources which contain mercury has to be used carefully. When these types of lamps get broken during their life hours or even after the usage, there is the risk of touching mercury based mixtures by people directly, via animals or via infected waters. As noxious substances of mercury can be absorbed through the skin, causing serious health problems such as skin cancer, they have to be disposed of as hazardous waste. Since mostly public are not aware of harms these light sources may cause, it is better to use incandescent lamps or LEDs to minimize the health problem. (Fabio Falchi, 2011) (Webb, 2006)

3.3.2 Blue Light Effect of LEDs

As discussed before in chapter two, LEDs are becoming the main light source in recent years. Animal modeling Researches by F. Behar-Cohen have shown the negative effects of blue and white LED lights; "Beside blue LEDs that are used commonly for decorative purposes, white LEDs provide retinal exposures to violet, indigo and blue light at much higher levels than in previous light sources. This is the first time that the population will be exposed to such substantial blue light." (F. Behar-Cohen, 2011) The research done by Falchi & Cinzano, also in 2011, completes Behar's researches and surveys light pollution impacts on human health, demonstrating how exactly blue light effect influences human behavior. Rather than two recognized types of photoreceptors (rods and cones) in human eyes, a third photoreceptor was recognized, "a circadian photoreceptor with wavelength sensitivity centered in the blue." The wavelength which white LED lights transmit is

between 440 and 540nm, the range which will stimulate circadian photoreceptor in the eye and these photoreceptors change the amount of melatonin production in brain. This means exposure to lightings with high blue component changes the amount of melatonin, which controls the circadian cycle in our body. Therefore the blue light effect may cause wide range of disorders such as, high stress level, insomnia and even cancer if we don't use filters which blocks under 530nm wavelengths. (F. Behar-Cohen, 2011) (Fabio Falchi, 2011) Complementary researches by Ann R. Webb shows how changes in melatonin cycle of body in different daylight exposures from winter to summer causes Seasonal Affective Disorder (SAD): " SAD is a type of depression whose symptoms become apparent during the winter months and disappear in the summer when the days become longer" SAD can be treated up to 55% by illuminating the patient with blue LED light, without considering other possible effects of melatonin change in the body, the 'Blue light effect' in high illuminated spaces can be useful in winters while causing disorders in summer, when the amount of melatonin production in body is naturally high. (Webb, 2006)(Theresa L. Shanahan, 2000)

The Blue Light effect will sure affect human behaviors. Since Light Emitting Diodes (LED) are the light source in new generation of digital screens and they are getting widely popular for various purposes due to their high efficiency in comparison with fluorescent and sodium lamps, physiological effects of LED light sources on human kind is strongly recommended for further investigations.

An important factor to be considered here is that although within the current lamp sources incandescent lamps are the most reliable light sources according to health issues, they are weakly in-efficient in terms of using energy. So considering all

parameters still LED lamps seem to be a better replacement for mercury based lamps due to their high efficiency and lower impacts on public health.

3.4 Qualitative Aspects of Lighting Design

Richard Kelly a well-known lighting designer in 1950's defined a guideline for a comprehensive lighting design. The importance of Kelly's principles was that the most usual critic about modernism for paying too much attention to the function cannot be applied to his guideline. Rather than the quantity of light by means of minimum standards and functional needs Kelly discussed qualitative aspects of lighting to be considered in architectural lighting design. Ambient luminescence, Focal glow and the Play of brilliant are three principles that Kelly brought up for a comprehensive lighting design are described below;

3.4.1 Ambient Luminescence

Ambient lighting refers to the general lighting of the surrounding. Ambient luminescence provides adequate illumination for orientation and visibility, mostly provided by down lights (Tzelepis & Nakos, august 2003). Ambient luminescence is needed while it does not play a major role but simply provides a background basis for more innovative lighting designs. (Veitch & Nesham, august 1996)

3.4.2 Focal Glow

Focal glow illuminates a specific space or object with direct light. While ambient luminescence provides background illumination, focal glow directs the eyes and creates hierarchies of perception. A direct light on the furniture in parks or on the entrance of a place can be considered as focal glow. Focal glow draws the attention to specify a function. (Veitch & Nesham, august 1996)

3.4.3 Play of Brilliants

S. Ghafourian (2008) defines play of brilliant as “the creation of a specific atmosphere with decorative lighting effects such as color, patterns and dynamic changes”. Lighting tools such as; decorative chandeliers, projectors, digital displays and neon signs can create a specific language of lighting for a specific space. “It is only when ambient luminescence, focal glow and the play of brilliants are combined that a lighting concept is complete” (S. Ghafourian 2008); (Veitch & Nesham, august 1996). By contrast with horizontal illuminance, “vertical illuminance is ideal to complement the functional lighting design as well as to become the basis for architecturally oriented lighting concept”. (Ghafourian 2008) Illumination of selected walls, or the whole façade of a specific building, creates a spatial focal point, and a kind of identity for that space and helps the orientation as well. Important touristic buildings, whether they are old or new, has the specific potential to become a key point in lighting master plan of a city especially if the surrounding has the potential to become a live public space. For example, admirable architectural lighting designs of “Casa Battlo” and “Casa Mila” in Barcelona, Spain, creates a dominant sign and arouses interest and therefore plays a great role in improvement of surroundings. (Fig 6,7)

Figure 6: “Casa Mila” in Barcelona – Spain. Not only the façade but also the roof with different lighting method is in conversation with the environment

Figure 7: “Casa Battlo” in Barcelona - Spain

3.5 Conclusion

"A good composition is an arrangement of elements that varies in quality when something is added or left out. A light composition needs both light and darkness to create a scene in which certain elements are accentuated, linking them one to another. The number and arrangement of these accents and the way in which they are connected forms the hierarchy of the composition" (Holland, 1997). Appropriate combinations of urban lighting elements lead to create a comprehensive lighting structure for public urban spaces. An example for Kelly's principles in urban scale may clarify the role of these factors;

Ambient luminescence: can be provided by street lamps and high mounted light sources in parks, plazas and squares.

Focal Glow: Depending on the users and the scale of the space, retails and shop's windows, lighting of urban furniture and monuments, public activities, important nodes, digital entertainments technics and advertisement screens can be considered as Focal Glow.

Play of Brilliant: This aspect strongly depends on the existing circumstances and the scale of each urban space. As an example in historic sites remains of important buildings have high potential to be illuminated with different point of view rather than the surroundings and play the role of brilliant in the lighting composition. Examples of each principle are shown in Chapter Five of current research.

Various researches on the effects of the light in indoor spaces have been done. Considering the rapid growth of outdoor lighting devices and fixtures in recent years

reveals the necessity of deeper investigation on the possible influences and potentials of public lighting as an urban parameter. As research findings showed the uncontrolled growth of lighting without considering human factor issues may cause such effects as health problems, light pollution and visual pollution which can make profoundly negative impacts on public. The result can start from hidden mild disease such as increase of stress level but may lead to serious physical or mental disease depending on different situations. So in order to benefit from the advantages of improved public lighting and to be able to simultaneously control the undesired influences of it in urban scale, a set of rules and guidelines are needed which is called "Lighting master plan". In the next chapter (chapt. 4) potentials and deficiencies of four examples of lighting master plans has been analyzed.

Chapter 4

LIGHT IN PUBLIC SPACES

4.1 Introduction

This chapter is focused on lighting in urban scale to achieve a better understanding of trends and movements of lighting in public urban spaces. The research tries to point out both states of art in lighting technology and potentials and new movements in urban lighting design in order to be able to suggest suitable lighting settings in next chapters which can absorb and eventually bring people back to the urban public spaces of 21st century cities.

Figure 8: Lamplighter lighting a gas streetlight in Sweden, 1953

Public lighting begins with candlelight and oil lamps in sixteenth century, and was improved by gas lighting in the beginning of nineteenth century. Arc lamps and light

bulbs were invented in twentieth century and it was after the First World War that the shortage of coal led to the greater usage of electric light which is the main source of lighting in public spaces. Between 15th and 19th century street lighting improved enormously and made groundwork for festivals, the first lighting event in urban scale. Many festivals were held, in which, public lighting became so popular in terms of new lighting technologies of the time like fireworks and candles in 15th century, gas lights in the beginning of the 16th century and eventually electric arc lights in 19th century were used to enrich both street lighting and festivals. A good example was the festival of St. Peter's Basilica in Rome, which "Johann Wolfgang von Goethe" had described in his logbook.Goethe explains his observations of the illumination of St Peter's Basilica; "To see the colonnade, the church and the mass, is a unique and glorious experience. When one thinks that, at this moment, the whole enormous building is a mere scaffolding for the lights, one realizes that nothing like it could be seen anywhere else in the world… The fireworks were beautiful because of the setting, but they did not compare with the illuminations of the church… It seemed entirely like a scene from a fairy tale. To see the beautiful form of the church and its dome as a fiery elevation is a view both grand and charming."

Figure 9: The illumination of St Peter's Basilica, Rome-Italy (1800-1825)

St Peter was not the only one, but the most important festival of the time. In 1547 decisions were made to attach stable candleholders around the dome to facilitate upcoming festivals of light. “St Peter’s Basilica was not originally built to be integrated with lights however, it is an early example of how, by fastening lighting fixtures onto the façade and structure of the building, light was successfully integrated within architecture and public spaces.” (Khodadad, 2003)

After collecting the basic facts such as, “what sort of light and how much, whether the illumination should be evenly distributed, direct or indirect, located on the building, directed at it or a combination of the two” (Christa van Santen), then the selection of the light source, the color combination, the material and the shape of luminaire and the reflector determines the technical answers for the correct lighting equipment for a specific space.

4.2 Lighting Master Plan

Until the 1980s public lighting was focused in specific parts of the cities rather than the whole. In the late 1980’s “festive lighting” was used as an encouragement for urban economies to invest more on urban lighting as exemplied in Paris. The result was comprehensive urban lighting plans in Paris which involved designing the first “lighting master plan”. (Enginöz: 2004) Various needs such as safety, commercial purposes and beautification have led to the rapid growth of outdoor lighting mostly without an organized plan. However the city should prepare to organize this growth with a comprehensive light info structure or otherwise this may lead to a vast chaos of un-organized lights, transforming the night view of a city into visual pollution. Currently, there is no systematic theory of urban landscape lighting planning. “It is possible that urban structure theory, which is commonly used in urban design, can

combine with the unique nature of artificial lighting design, and ultimately form an independent theoretical system." (Sun Xiaofei, 2010)

A comprehensive understanding of suitable lighting is needed in order to prevent this pollution. For this purpose a set of rules and guidelines is needed to ensure the balance and harmony between lighting of different sections such as streets, pedestrian paths, plazas, squares, parks, parking, monuments and architectural lighting in each zone of the city. Lighting plan controls the illumination of each urban zone as well as the unity between them as a whole. This set of rules and guidelines for a zone or the whole city is referred to the "Lighting Master Plan". (Hereafter L.M.P will be used as an abbreviation of Lighting Master Plan.)

4.3 Lighting for the Definition of Space

Architects and urban designers form the daytime face of the city, while lighting designers are creating the different world of "night life". The important issue is that whether the lighting design reflects the day character of the city or transforms it to a completely different shape, it has to boost the identity of each zone and in bigger scale; each city.

> "Many advantages can be gained by discovering and reinforcing a city's own identity. Small differences may be magnified, special events may be commemorated, designers may seek to set their stamps on projects, and many other motives may encourage efforts to undertake the quest for urban identity… how to give the area its own physical identity, and how to make it a place with its own character, distinct from that of other places, is the first aesthetic problem in the design of the district" (Oktay, 2002).

Considering the identity of an urban space according to Rapoport (1984) the following characteristics shape a recognizable space; the location, relation to landscape, having certain elements, certain settings and spaces of certain type, being

named in particular ways, using certain orientational systems, having certain colors, textures, sounds, smells, temperatures, air movements and having certain people engaging in certain activities. (Rapoport 1984) Here the role of urban lighting had been ignored. People's experience of urban districts in the daytime can be extended into night via urban lighting. The definition of a district is primarily based on the atmosphere and character of the area and urban lighting significantly determines the nocturnal character of the districts. Emphasize on the daytime character of the city increases legibility although lack of variety and harmony may lead to a monotonous night time image. Moreover, urban lighting highlights the important spots and nodes, such as marking the transportation stations, public services, police or security spots and important 'happenings' such as special events. Lighting also defines the areas of different functions in nodes (such as squares), and emphasizes and boosts the aesthetic properties of nodes. (Unver 2009)

The above mentioned factors implies that instead of presenting a set of singular points that draw the attention of people in an unorganized nocturnal layout, a Lighting Master Plan is needed in order to provide composed nocturnal silhouettes at night by considering safety, aesthetics and the harmony between lights as well as environmental issues such as using energy efficient light sources, replacement and recycling of the mercury lamps and controlling the overall light intensity to avoid light pollution. L.M.Ps are long-term programs for city governing authorities and needs several years in a strategic approach to get completed.

4.4 Smart Lighting

"Time clocks were the first automated controls applied to lighting, allowing lights to be turned off when it could be assumed that no one would be using the space."

(LLC, 2011) Smart Lighting Control refers to a system that controls the on/off condition of lighting. “The term; [intelligent lighting system] refers to a system where multiple lighting fixtures are connected to a network, and user needs are met by cooperation of the lighting fixtures.” (Mitsunori Miki, 2012) Smart lighting in indoor uses usually detects the human occupancy and based on their detection of motion adjusts the amount of light needed for a specific area. The main purpose of smart lighting is to save energy, however the system is being used in a wide range of applications nowadays such as street lighting, commercial uses and beautification of buildings and public spaces. Another purpose is to control by detecting movements on streets to provide security.

Every smart lighting system needs a controller. In small settings like houses or small buildings an infrared sensor can detect the absence of occupants and turn the waste lights off, However, large lighting systems need a master controller which runs the application from a computer or over the internet. (Lighting the future 2011)

4.4.1 Intelligent Lighting

Intelligent lighting is an improved model of smart lighting by using a combination of artificial intelligence and smart lighting in which, instead of central control unit light learns to respond to each location separately, by means of feedback. The most important difference between S.L and I.L is that the latter has the ability to analyze the results through time and make better decisions. “The term ”intelligent lighting fixture” means lighting which has a controller called a learning device. This makes it possible for each individual lighting fixture to operate autonomously based on the illuminance information that flows through the network. There is no central control unit, so it is easy to add lighting fixtures and illuminance sensors while the system

has high robustness against malfunction, and a high reliability system can be achieved even in large-scale buildings." (Mitsunori Miki, 2012)

4.4.2 Smart Street Lighting

The Phillips Corporation in 2008, designed the Sustainable City Light for their Simplicity Event in Moscow. The concept revolves around solar powered LEDs for street lights and incorporates a design based on how flowers open up their petals to collect sunlight. These Sustainable City Lights use photovoltaic panels that open up in the day to capture the light to be transformed into energy and at night when the panels close LED lamps start to emit light. This intelligent lighting system is designed to provide lighting when required on demand. The lights also have the feature of being motion sensitive and operate the LED lights only on sensing movement in the vicinity. Grid power can also be used with these lamps to supplement the solar power where and when required. (Philips, 2012)

Figure 10: Smart street lighting designed by PHILIPS

4.4.2.1 Intelligent Street Lighting – Delft City – Netherlands

Street lighting in the Netherlands costs 310 Million Euros annually. The existing street lighting costs more than 50% of municipalities' annual electricity budget. Delft

has the goal of becoming completely energy neutral by 2050. Technical University of Delft conducts ‘Twilight’ research project on the intelligent street lighting of Delft City to solve this problem. One of the major challenges in this project is that public lighting is turned on all nights even when nobody is using the space which is a big waste of energy. ‘Twilight’ project has designed an electric kit which fits into existing street lights and turns them to an intelligent lighting system. Followings are anticipated improvements accounted for this system;

Intelligent street lighting dims the light to 20% if there is no one in the vicinity, while increases to 100% as soon as passerby comes within range. This will save energy up to 80%. (Fig 11)

In this system not only lamps are connected together, but they are also connected to control center. For example they can contact the center and inform that a specific periodical lamp is going to fail in few weeks or it has been failed due to an accident and has to be replaced. This system saves up to 50% of operation and maintenance costs. Prof. Gijs van Kuik manager of ‘Twilight’ project points out following advantages;

- The cost recovery of ‘Twilight’ project is predicted to be between 3 to 4 years which makes it quiet logical to be used in public lighting.

- From the aesthetical point of view, the light ‘travels’ along with people, a bit ahead of them which seems to be a comfortable feeling.

- People who are responsible for the maintenance are also pleased about this since lamps posts give the signal when maintenance is required.

- The system is so simple that can be applied to all the existing lamp posts. (Technical University of Delft, 2012)

Figure 10: Intelligent street lighting proposed by TU Delft saves up to 80% energy

4.4.3 Lighting Control Strategies and Technologies

Lighting strategies are conceptual descriptions for change demands for lighting and the way a lighting system should react. Three systems for smart lighting will be discussed below. These are network systems which include the Wireless network, the Infra-red network and the Visible-light system.

4.4.3.1 Wireless Sensor Networks (WSN)

This system is more efficient where the series of lamp nodes can get connected together such as street lighting, parking lots, parks and pathways. WSN enables the lighting system to exchange data between lamp nodes so each node should at least enable a few other nodes. This system includes Light Control Nodes (LCN), sensor

nodes (SN), and a Base station which periodically mentions the presence of all nodes and sends the relative information via a wireless connection. However, instead of a base station which has to send very powerful wireless waves and has low accuracy, both Master Nodes (MN), and Sensor Nodes (SN) can act as a base station. (A.A.Nippun Kumaar, 2010) (Maciej Mendalka, 2010)

The figure below (Fig 12) illustrates a street lighting model using a wireless network suggested by Nippun (A. Nippun Kumaar, 2010. *Intelligent Lighting System Using Wireless Sensor*). The system is integrated with street lighting system by author. This figure (Fig 12) shows the relation of these nodes and the way this system should be implanted so that it can be applied to street lighting. In this model all nodes (street light posts) are LCNs, each 3 nodes needs one sensor node so one third of all nodes are SNs as well. However each 13 posts just need one MN which analyzes the datas received from all 13 posts in its wireless range, makes the decision and sends back the order to nodes.

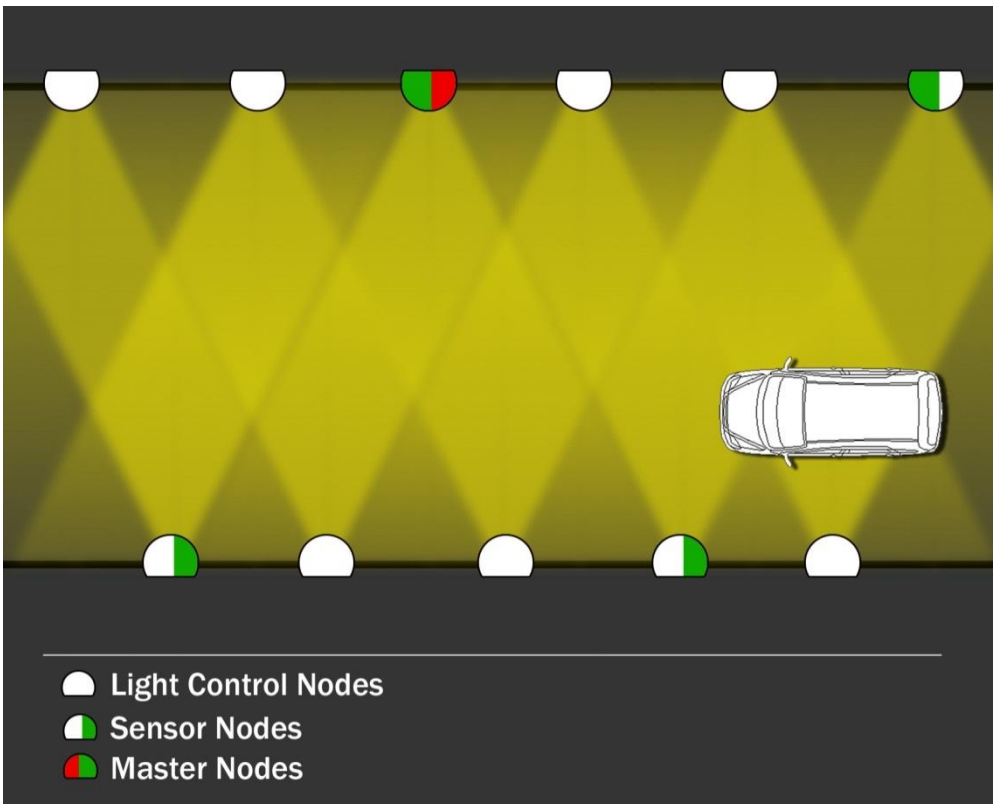


Figure 11: Smart street lighting modeled by Author based on Kumaar's wireless network (Figure by author)

In this model Sensor nodes sense the environment and feedbacks the light level to the master node. Then the Master node sends the required light information (feed forward) to each node individually and the light control nodes respond to the master nod by dimming or brightening the light according to the data received. Each sensor node ensures the performance of 5 posts and each two sensors has an overlay of two posts which ensures the performance in the situation if one sensor fails to analyze correctly. This arrangement will make the light control precise while reducing initial costs compared with the primary wireless models. In the case of poor weather condition or accidents, which harm the light posts and reduce the amount of light, the master node responds and covers the overall illumination by controlling LCNs.

4.4.3.2 Passive Infra-red System

Infra-red system is mostly efficient for indoor purposes such as exhibitions and museums. This system is a worthy replacement for video camera applications which are mostly expensive and also have personal privacy problems. “A PIR sensor is a device that measures infrared (IR) light radiating from objects in its field of view. PIR sensors are often used in the construction of human motion detectors.” (Li-Wen Hung, 2011)

4.4.3.3 Visible-Light Communication Technology

Visible-light communication (VLC) technology uses visible light to conduct communication; it has been receiving attention recently as an efficient communication technology for specific places. Compared with the technology of infrared communication, visible-light technology provides advantages the following;

- Because electricity used in lighting can be applied directly to communication, it is possible to construct a wireless communication environment with simple equipment.
- It can be used in areas where electric waves are restricted since light is not restricted by current radio laws.
- Transmission and reception can be confirmed visually since communication is conducted via visible light.

These factors make visible-light technology very efficient for the design of security systems. (Mitsunori Miki, 2012)

4.5 New Movements in Urban Lighting

LED outdoor Display System is a multimedia hi- tech product that combines optical, electronic and acoustic signal processing technology. It includes a display screen, controlling computer, communication system, system software & related peripheral equipment. The screen connects to an external scanner which acts like a graphic card, and accepts pictures, graphs, dynamic images, animation or any video output from TV, VCR, DVD,etc, or from a central computer. The control computer can act as a workstation on network, and read real-time data from specified computer, and show on its display or play pre-recorded document. (Shenzhen ERALED Optoelectronics Co., 2012)

4.5.1 Digital Facades and Digital Screens

Digital technology gives the opportunity of transforming the whole building's façade into a large electronic screen. This gives an ultimate possibility to change the façade according to needs. In such buildings, rather than the architect, visual artists and lighting designers form the image of the building, especially during the night. Digital facades can perform as an urban scale exhibition which can make a great improvement in the quality of public spaces. The picture below (Fig 13) shows one of the early examples of digital facades for an office building in "Potsdamer platz" project in Berlin – Germany, designed by "Rentzo Piano" in 2006.

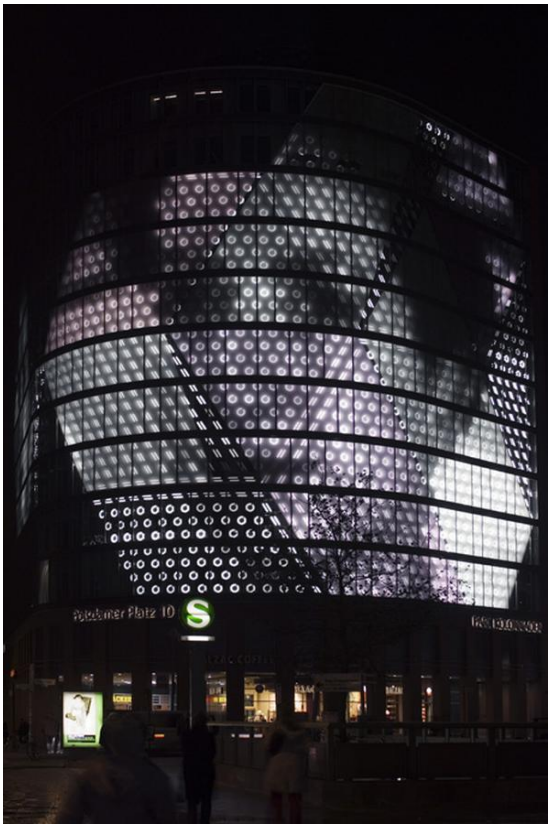


Figure 12: Façade as an exhibition – Potsdamer Platz , Berlin - Germany. (source: archdaily.com)

“City Gaze’ (Die Stadt hat Augen) is an exhibition that pursues a unique concept. An office building on Potsdamer Platz is being transformed into a visual art object. From 24 November to 28 February 2006, SPOTS, a light and media installation that has been integrated into the building’s facade, will be presenting new works by internationally renowned artists that have been created especially for this location and this medium.” (Winkleman, 2006)

Although digital facades can be used in various innovative ways, the excitement of using new technologies sometimes makes the designers ignore some valuable factors in terms of architecture and urban design. In the pictures below (Fig 14) different scenarios of the digital façade of “Medialab Prado” in Madrid (Spain) is shown, designed by “Langarita Navarro Arquitectos”.

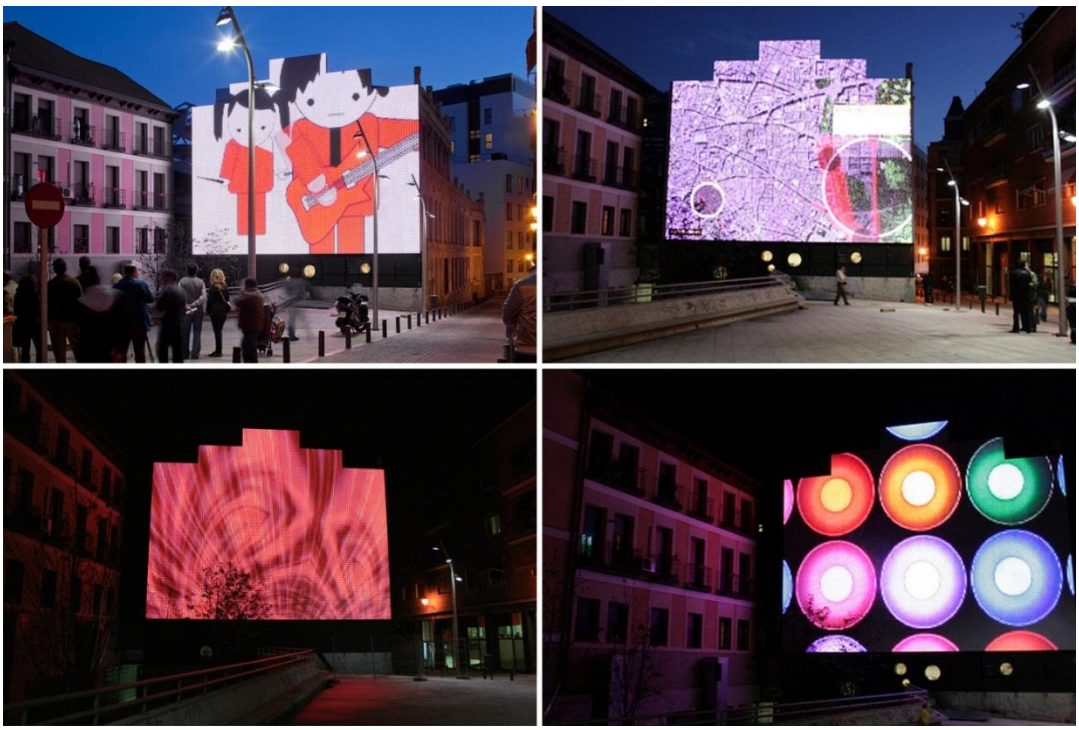


Figure 13: Different scenarios of digital façade of “Medialab Prado” – Madrid, Spain (source: Archdaily.com)

Figure 14: Daytime view of “Medialab Prado” (source: Archdaily.com)

As can be seen from the day-view of this building the flat LED screens which create the building’s façade and facing a public urban space, consists of a flat monotonous surface without any architectural details. This is not human scale and in a deep contrast with the surroundings. The building provides nothing to pedestrians or to the

public space in front of it but a commercial message of being a high tech company just like an advertisement screen. In brief it can be stated that large scale digital façades can be more useful adjacent to high ways or other places in which the screen can be seen from a far distance.

New adjustable LED screens can get adapted to different forms rather than rectangular forms and do not need massive infrastructure. Therefore this technique has also been used in urban lighting. As it can be seen in the pictures below(Fig 16), LED screen is adapted to an existing bridge in Eindhoven – Netherland. In this case, the displaying picture determines the volume, quality and color of emitting light.

Figure 15: Bridge lighting using LED screens – Eindhoven. Source: www.Hollands.info

4.5.2 Advertisement Screens

As the brightness of Digital LED screens is much more than the former versions (statics screens), one of the primary effects of these screens on the surrounding is the "Glare" effect. Figure 17, shows high contrast between new implanted LED screen in a roundabout in Famagusta, a developing city in Cyprus, and general lighting of the environment. Such condition may cause glare or even temporary blindness which is

really unsafe especially for drivers. Another consequence of the new screen is disturbance in the harmony and composition of urban illumination.

Figure 16: LED screen extremely inharmonious with surroundings in Famagusta-North Cyprus. Figure by author

The future of this phenomenon can easily be seen in developed cities such as Tokyo, where the high percentage of urban edges had been already transformed to large scale LED screens. (Fig 18)

Figure 17: General illumination of a public urban space in Tokyo – Japan. Source: urbandevelopment.blogfa.com

Figure 18 is an image of a public urban space in Tokyo and reveals the overall illuminations of urban edges that are much brighter than the pathway. The overheaded brightness of advertisement screens leaves the pathways dim and obviously causes unpleasant glare effect for pedestrians. Also research by Fabio(2011) , Behar-Cohen(2011) and Pode(2009) had shown the drawback of blue and white LED lights on circadian cycle of the body. By the changes these lights make in melatonin production of the brain, therefore such diseases as insomnia, high stress level and even cancer may emerge depending on the length and intensity of radiation one is exposed to. This survey pointed out that there are three negative effects of LED screens; 1-Glare 2-Harmony disturbtion 3-Circadian cycle disorder. Further researches are essential to examine other possible effects of LED screens in order to survey the necessity of controlling guidelines for these products.

4.5.3 Urban Furniture and Structure Lighting

Lighting for urban furniture such as benches, lamp posts, pedestrian separator pillars and other components, has always been considered to be visible, however new trends in urban furniture design have gone further than this by considering lighting design in the design of urban furniture, giving them more aesthetical view. (fig 19,20,21)

Figure 18: Urban furniture mixed with lighting

Figure 19: Pedestrian separator pillars mixed with lighting

Figure 20: combination of furniture and lighting designed by Ross Lovergrove.
source: designer's website

Urban structural lighting is the state of art in urban lighting design. Some of successful examples of urban structural lighting can be seen in Eindhoven-Netherlands. "Har Holland" who is a Dutch architect and lighting designer, has taken all urban structures into consideration, including bridges, monuments, electric beams and whatever can be illuminated in the urban scale and designed creative lighting for each case. The pictures below (fig 22) show some of lighting design projects by Har Holand's office, mostly located in Eindhoven which plays a great role in aesthetical improvement of the city. Most of these projects are dynamic in terms of lighting (in opposite with static lighting), showing us how smart dynamic lighting as the cutting

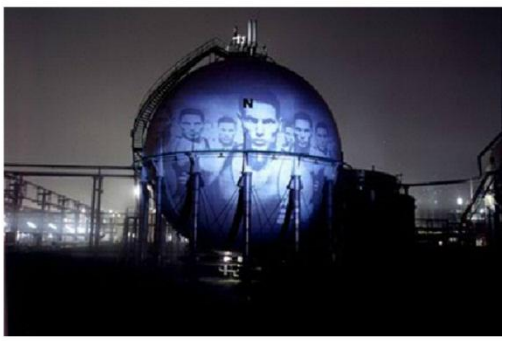
edge in urban lighting design, can be applied in different scales and make different appearances for the existing urban elements.

Silos

Cooling installation

Broadcast tower

High voltage



Tanks

Figure 21: Urban structural lighting by Har Hollands" show us how lighting can give new aspects to the night life of the city by illuminating the existing elements. Source:www.hollands.info

4.5.4 Projection in Urban Scale (Video Mapping)

Projection technique is inspired from cinematography by means of projecting movies, in early versions, into a white screen. However, today improvements in projection industry makes this technic available to a wide range of users by reducing size and primary costs. The system requires minimum facilities including a projector (for small applications), a computer and access to electricity which allows wide range of users such as urban projection artists to hold a mobile art exhibition.(fig23) This technic is currently being used in wide range of events and applications such as light festivals and commercial purposes.

Figure 22: Mobile projection system for temporary uses. source: Flickr.com

Figure 23: Projection of visual illustrations on Sydney Opera House during the Festival of lights source: Flickr.com

3D projection is any technique of mapping three-dimensional points to a two-dimensional plane. As most current methods for displaying graphical data are temporary installations based on two-dimensional media. The use of this type of projection is becoming common, especially in computer graphics and visual arts. Video artists are able to match video to buildings, and resample different visual

effects. This method is being used in many light festivals and similar entertaining purposes.

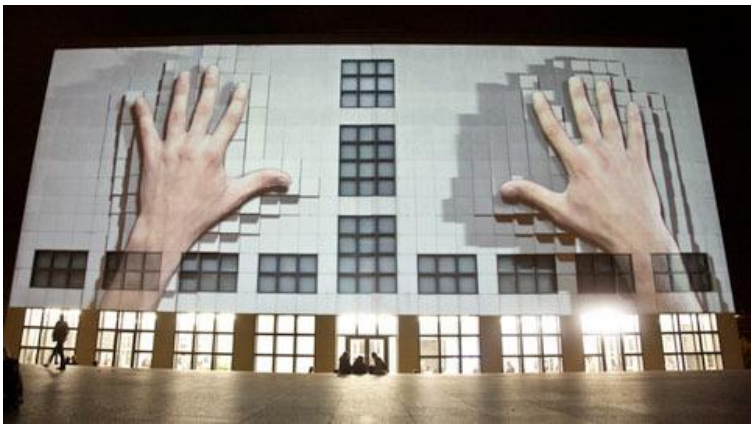


Figure 24: 3D projection on building's façade source: Flickr.com

Figure 25: Transformation of building's facade to a digital illustration via 3D mapping projection source: Flickr.com

4.5.5 Festivals of Lights

One of the most important light festivals is Berlin festivals of lights in Germany. Starting from 2004, The Festival of Lights is an event in Berlin , where once a year in October for one or two weeks the city hosts illuminations , fireworks , artistic light projections and other events related to lighting. Buildings, streets and squares, such as the Brandenburg Gate , the TV tower , the Berliner Dom and the Victory Column get a new face each year by latest technologies in lighting designs. Like other similar festivals, the Berlin Festival of lights represents the state of art in lighting technology and design. (Festival Of Lights, 2012) The seventh light festival was held in 2011 in Berlin and consisted of 80 installations and hosted 1.5 million visitors. special "lightseeing" tours were provided on the 'Light-Liner' bus, by boat on the 'Light-Ship', on foot with the 'Light-Cruso' or by rickshaw with the 'Light-Velo' for locals and visitors giving them the chance to visit and experience the whole composition." (Berlin Festivals, 2012)

Sydney in Australia also held the fourth annual "Vivid's Festival of Light 2012" celebrating creative industries with light shows, music, design ideas conferences and entrepreneurship conferences. The seventeen-day festival features light shows and graphics projected on buildings, concerts, lectures and conferences. "This round of light projections will have over 50 installations and includes cityscapes, street furniture, monuments and emblematic buildings like the Sydney Opera House." (Vinnitskaya, 2012) (fig 29) "A group of light projection specialists from Sydney, use the facade of the 'Customs House' to present "City Life". Between the sights and sounds of people, cars and weather patterns the miniature city transforms over the course of six hours in a night."(fig27) (vividsydney, 2012)

Eindhoven city in Netherland also hosts a light festival calls "Glow" every year in November which is the second largest light show in Europe after Lyon in France. Further information about lighting of these cities is provided in chapter five of the current research.

Figure 26: "City life" lighting installation on Custom House' façade – Vivid Festival of Lights, Sydney 2012 Source: archdaily.com

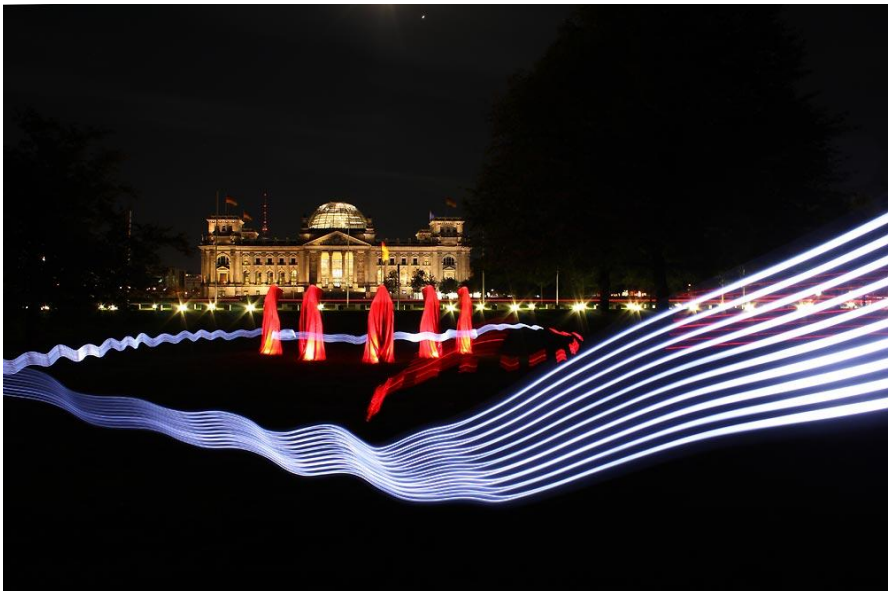


Figure 28: Lighting of Reichstag building and the adjacent urban open space during Berlin's Festival of Lights 2012

Figure 28: Projection on surfaces of Sydney Opera House - Vivid Festival of Lights, Sydney 2012 source:archdaily.com

4.6 Conclusion

Research findings in chapter three pointed out essential aspects of lighting which has to be considered in public lighting including primary expectations like visibility and glare prevention and also issues which may affect user's behavior and health. In chapter four the study focused on different aspects of lighting in public spaces such as lighting festivals as one of the first lighting movements in urban scale, latest technologies in lighting industry and new movements in lighting design. The research findings showed several factors are related with lighting that can play a role in bringing back people to urban public spaces. However the main point is that since each factor is related to different industry or organization, so they cannot be applied in urban scale unless all of them get controlled by Lighting Master Plan. Urban lighting has a vital role in absorbing and bringing people back to public spaces, which has led to wide application of lighting in different outdoor activities and events. Light festivals are one of the most important events related to outdoor lighting. Such festivals show the latest available technologies which can be used in L.M.Ps by gathering related industries together. Also these festivals raise public's awareness about the importance and effectiveness of light and lighting.

Since one of the main concerns of public to be in a public space at night is visibility and safety, smart and intelligent lighting systems can also play a great role in inviting people to public spaces. Smart lighting eliminates the need to cut the light after a specific time at night therefore assures public that they will never be in a dark or dim public space.

Chapter 5

LIGHTING MASTER PLAN EXAMPLES

5.1 Introduction

Up to now the research pointed out the importance of Lighting Master Plans to achieve a comprehensive, healthy and affordable lighting which brings people back to urban public spaces. Since L.M.P is a new issue, very few sources are available in academic sources such as journal articles, books and online sources, and has been rarely discussed and analyzed by academicians. In other words there is not a reliable framework available to examine a L.M.P. In chapter five three examples of L.M.Ps has been analyzed to achieve better understanding of how L.M.Ps can be applied to a city or a zone, and how city's potentials have been transformed to lighting design opportunities in order to arouse public's interest and get people back to the urban public spaces during the night. Since 'Lighting Master Plan' can be applied in different scales, three examples has been chosen in a way to conclude different scales. First lighting master plan in the scale of city; Lyon. Another reason for chosing it is that this city is well-known as the pioneer of lighting design and management in urban scale. The second example is the downtown distict of 'Stuttgart' which is an example of implemention of lighting plan in the scale of a district. And the third one is 'Vancouver's Southeast False Creek' an example of lighting plan for a zone. Between these examples the second one (Stuttgart's Downtown) is more similar to the case study (Famagusta Walled City) from the scale point of view.

In the book 'The Image of the City' by Kevin Lynch, he speakes about the "imageability", or "that quality in a physical object which gives it a high probability of evoking a strong image in any given observer." (Lynch, 1960) " The imageability of a city is linked to the five elements he has defined: nodes, paths, landmarks, edges, and districts, all of which can be observed by anyone in any city. Between these five concepts intertwining and interacting, a person can develop their own image of a city, an interesting convergence of the personal conception and public physicality."(http://adashofdesign.wordpress.com, 2012)

In order to determine the night time face of the city, Lynch's sections have been translated to night urban sections which have the potential to be illuminated. These sections can be considered as components of lighting master plan;

- Streets (paths)
- Walkways and bikeways (paths)
- Building facades (edges)
- Water fronts (edges and combination of paths and nodes depending on the urban organization)
- Districts
- Plazas and Parks and other open spaces (nodes and landmarks)
- Historic buildings, notable architecture, public art and monuments (nodes and landmarks)

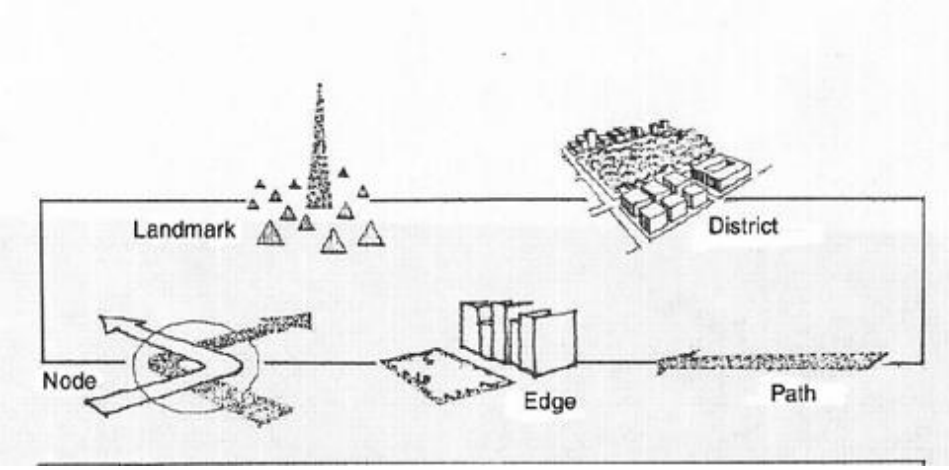


Figure 29: Lynch's five concepts that develops the image of the city

5.2 Lyon; The City of Lights

Lyon, the second largest city in France is a pioneer in L.M.P design since 1989, when the first lighting master plan in the world was implemented in this city. Lyon created a unique image with artistic lighting design by lighting more than 250 sites throughout the City. The emphasise was on public spaces and monumental buildings of the Renaissance heritage such as banks of the Rhone , Hôtel Dieu, City Hall, Gerland Park, the universities, bridges, etc. (Aderly, 2008)

Figure 30: Night time time image of Lyon (Source: http://www.lyon.fr/vdl/sections)

Figure 31: Daytime image of Lyon (source: citypics.com)

Since then, lighting became not only a tool for assuring the nighttime security, but also became an essential aspect of urban development and one of the most important elements in tourism activities. (Lyon.Fr, 2006)

As a result of the success of the first lighting plan, since 1995 Lyon has been exporting its expertise in urban lighting for monumental buildings to Russia, Havana and Vietnam. Fifteen years later, in 2004 a second light plan as an update of the existing one was prepared with a focus on the physical properties of the city such as hills, rivers, silhouettes and main arterial roads. Figure below (Fig33) shows the general overview of the existing urban L.M.P of Lyon. Five basic features in Lyon's lighting plan were defined;: spots, halos, heritage areas, urban development areas, and lines of movements which can be seen in figure33.

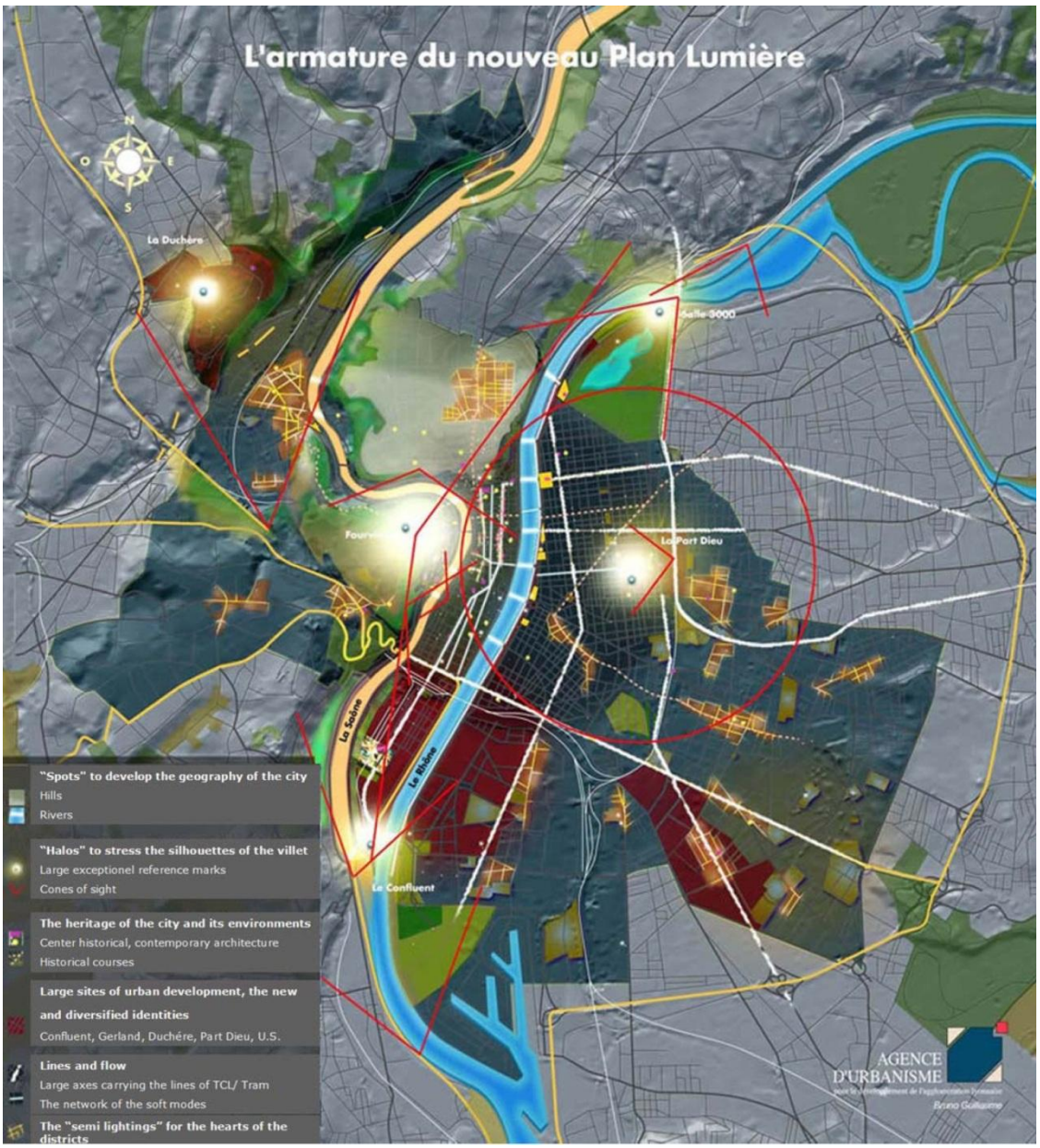


Figure 32: The New Lighting Plan of Lyon Source: http://www.lyon.fr

Lyon was analyzed on the whole and divided into different zones to highlight their individual character. Each zone is confluence of different functions such as Public spaces, Parks, architectural monuments and landmarks. Since bridges had played a significant role in Lyon's history, attention has been paid to illumination of these bridges emphasizing on Lyon's historical character.

Figure 33: Bridge lighting in Lyon

Figure 34: Bridge lighting in Lyon Source: http://www.flickr.com/photos/davidthibault/6018483635/sizes/l/in/photostream/

Figure 35: Bridge lighting in Lyon - Source: http://www.flickr.com/photos/meilhac/3415995624/sizes/z/in/photostream/)

Special attention were paid to maintain and reflect unique character of such ditricts as ‘Part-Dieu’, ‘Fourviere Basilica’ and ‘La Duchère towers’ while maintaining coherence with the rest of the lit environment. For instance ‘Part-Dieu’ which is the old part of the city was illuminated with warm colored lamps to achieve the atmosphere of the ancient city of Lyon. (fig 37, 38)

Figure 36: Part-Dieu in Lyon (Source: http://www.lyon.fr/vdl/sections/en/)

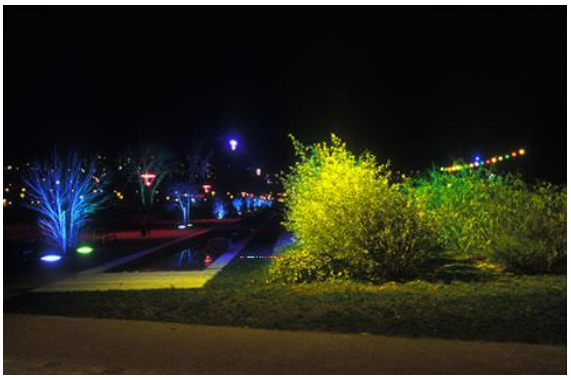


Figure 37: Landscape lighting in Lyon (Source: http://www.lyon.fr/vdl/sections/en/)

Lyon’s Lighting Master plan was intended to develop several lighting schemes that change trough the time while providing a dynamic visual environment for the urban dwellers. These smaller scaled installations could be provided in the city as forms of artistic installation or street furniture. These would be provided periodically and their lighting level should respond to the time of day to provide a lit space of appropriate brightness. The figures below (fig 39,40) are two examples of temporary lighting installation during the annual light festival in Lyon. Figure 39 is a light installation designed for an office building which is normally inactive during the night. Considering Lynch’s sections, this building can act as a landmark in the scale of zone and attract people to public spaces around it , while the other one (Fig 40) can be considered as landmark in city scale. Landmarks are essential urban sections in both zone and city scale and these installations draw attention to transformation of

existing inactive buildings to an active urban landmark or urban edge depending on the scale of the building.

Figure 38: Use of Colour Lighting during the Festival of Lights acts as a landmark in the scale of district (Source: PLD Magazine no.25)

Figure 39: Transformation of a middle rise building to a light installation during the Festival of Lights, Landmark in the scale of city (Source: PLD Magazine no.25)

5.2.3 ‘Parc de Gerland’ Lighting Plan

“Parc de Gerland” in Lyon is a unique public space that was allowed to be different from the main lighting master plan and became an example which implemented a totally different manner in the illumination of greenery. Careful analysis had been done regarding the quality of the proposed lit environment and the design objectives behind the lighting designer’s ideas for this park. Lighting within the Park had revolutionized the manner plants had been illuminated formerly, whereby the designers’ new main concept was an ‘impressionistic park’.

Figure 40: Primary sketches for transforming the park to an impressionistic park. (Source: PLD magazine no.25)

Figure 41: Parc de Gerland in the day (Source: PLD magazine no.25)

To create a different visual experience that differed from its daytime image nature has been illuminated, not in their true form, but saturated colors are projected and blended with the original hue of the flora, creating dramatic visual experiences. Three different entrances of the park were illuminated with different colors enabling the park to be legible while facilitating navigation. High mounted lamps had been implanted in order to minimize direct eye contact with the light source. (Unver 2008)

Figure 42: Computational rendering of lighting concept and fixture locations

To minimize distortion of appearance and achieving a blend of original colors of lit objects and the projected lights, most of the lamps are metal halide which has a high color rendering index of 90 and burning hours of 9000 hours. Color differences were achieved by using related color filters. The whole lighting composition has two different scenarios according to the activities taking place in the space which is provided by 16 lighting controls. Scenario ‘A’ is fully illuminated spaces from dusk to one AM and scenario ‘B’ is the basic lighting for safety and security from one AM to dawn. Although the lighting scenarios can be considered as a smart lighting plan to reduce energy consumption, however, new occupant detector technology provides much more practical solutions via intelligent systems which cuts of the light when it is not needed.

Each part within the park is delegated with their own color schemes, either complementing or contrasting with each other.

1. Yellow and mauve for entrances and gateways

2. Blue for large meadows and blue and green for large trees

3. Flowerbeds in static interplay of red, green and blue, together with their contrasting colors

4. Avenues and paths are in mauve, red, orange, yellow, green, blue and violet

5. Skaters area, dynamic display of colors

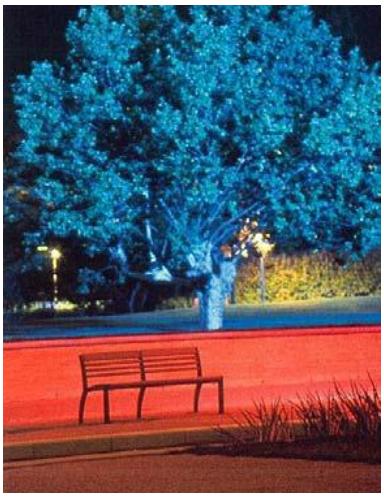


Figure 43: "Contrast of colored lighting (Source: PLD magazine no.25)"

Figure 44: "Use of saturated colored lighting on vegetation (Source: PLD magazine no.25)"

Figure 45: "Use of saturated colored lighting on meadows (Source: PLD magazine no.25)"

The analysis of ‘Parc de Gerland’ showed us how lighting can change our perception of lighting of greenery spaces and transform a public space to an artistic atmosphere. The innovative use of colored lighting in this park to increase the legibility while providing design objectives was one of the significant achievements of this project. Another important issue related to this example is the scale of this project which is similar to the scale of research’s case study.

5.2 Stuttgart - Lighting Master Plan for Downtown

The lighting master plan for the downtown of Stuttgart in Germany in 2004 was designed to reduce the high level of light emission from building facades, redesign the undifferentiated lighting scheme and reach goals of sustainable lighting design. These lamps are both harmful to health, due to mercury leakage after disposal, and also for energy saving. “The luminous efficacy of the old luminaires was relatively poor. The absence of optical elements resulted in glare on the one hand and undesirable nightglow on the other. In addition, the antiquated ballasts wasted a good deal of energy.” (Hess worldwide 2012) As Stuttgart’s municipality states, the following sectors were in the Lighting plan’s main structure to provide a distinguishable night time character and solve above mentioned problems with the existed lighting fixtures of downtown district. (City of Stuttgart, 2010)

- Stuttgart City Light
- Border ring
- Stuttgart miles
- Squares, parks and panoramas (Important nodes)

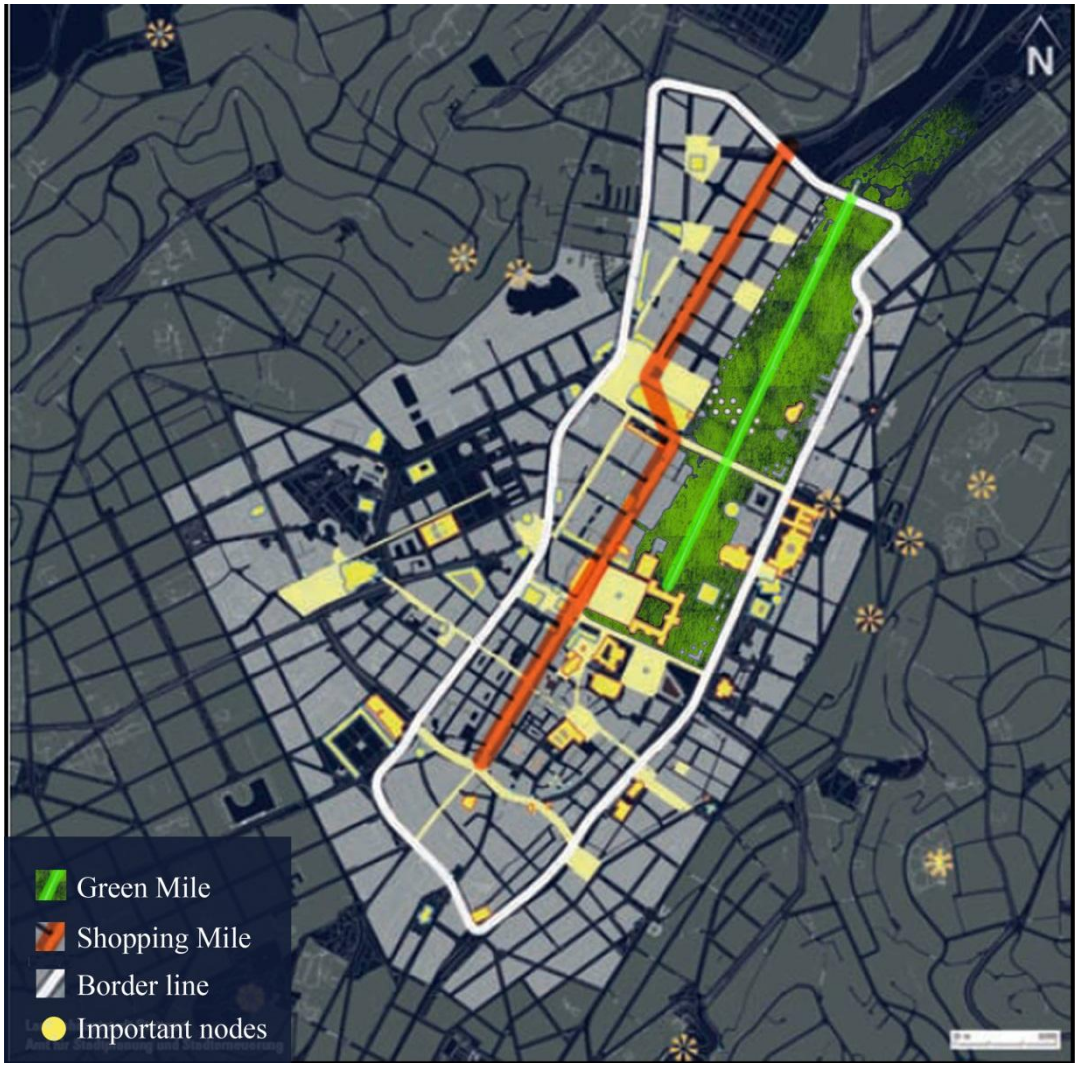


Figure 46: Definition of Border line, Stuttgart miles and important nodes in Stuttgart's areal view

5.2.1 Stuttgart City Lights

Replacement of old Stuttgart ball lightning, which was based on mercury vapor lamps, started in 2006. At most of sites within the project area, light posts have been replaced with new ones. “The new light cylinder, the "Stuttgart City Lights" is now put into operation. Their luminosity is so high that their focal points number was reduced from 600 to 400. Thus, up to 50% of the electricity costs can be saved.” (City of Stuttgart, 2010) In figure below (fig48) new pedestrian lighting fixtures can be seen. Although the goal of reducing energy consumption was achieved, new

fixtures clearly have glare problem since an uncovered light source is easily visible and light beams are emitted close to eye level.

Figure 47: New city light fixtures reduce energy consumption but also causes glare effect for pedestrians.

5.2.2 Border Ring

The downtown district of Stuttgart has different driving rules from the city. The Ring road lighting was proposed to emphasize on the boundaries and inform drivers about entering into the limit zone. Designer's solution was to implant a set of red LED street lights in addition to normal street lights, at the edge of the downtown district to inform drivers about entering into downtown. Figure 49 shows the schematic image of the ring of red lights that defines the boundaries of downtown.

Figure 48: schematic image of Ring road lighting, defining the boundaries of Stuttgart's downtown district Source: Knappschneider (2008); "Lighting Masterplan of Stuttgart"

5.2.3 Stuttgart Miles

There are two main active axes in Stuttgart which specifies two linear districts, and each has a different character. These axes have been boosted by the lighting plan of Stuttgart while considering their functions and activities. The Shopping mile is the main pedestrian access zone and is full of retail stores where shopping and window-shopping is the main aim of pedestrians. "During the hours of darkness, public lighting together with the lighting of the shop windows creates an attractive and pleasant atmosphere" (Unver 2008)

Figure 49 "Green Mile" "Source: LRS (2007), "Lichtmasterplan Innenstadt Stuttgart: Gesamtkonzept zum Umgang mit Licht in der Innenstadt-urzfassung", Wuppertal, Germany, p13"

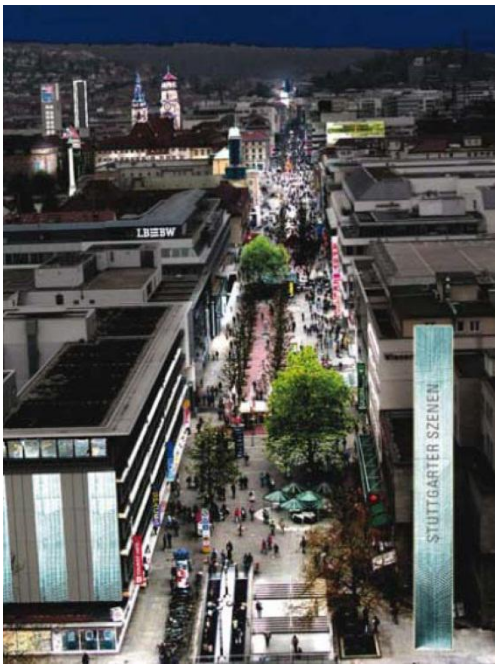


Figure 50:"Shopping Mile" "Source: LRS (2007), "Lichtmasterplan Innenstadt Stuttgart: Gesamtkonzept zum Umgang mit Licht in der Innenstadturzfassung", Wuppertal, Germany, p13"

The Green mile refers to a linear park which also includes some historic sites in it. “Lighting plan aims to give a differentiated character to the castle gardens without intervening the existing usage, the layout of paths or the landscape gardening” by providing light installations which can be experienced from different angles in park routes which had also increased the safety of these routes. “In this way the axis will link up the different sections of the castle gardens and thus become a new highlight for the night walk to the opera, theatre or museum.” (Unver 2008)(fig50)

5.3 Vancouver's Southeast False Creek

Southeast False Creek includes 32 hectares of Vancouver's downtown brownfields. As A. Paskovic states in her study (2012) sustainability, economic vitality, ecosystem health, and community health, were main policies to be considered in development of waterfront access, parks, and public plazas of this area. The last lighting strategy for Southeast False Creek refers to '2006 Southeast False Creek Public Realm Plan'. Although the plan suggests a framework for conceptual design in public spaces of this region, "compared to other design components, urban lighting receives limited attention. Key principals of urban lighting, such as energy efficiency, colour rendition and glare, are mentioned by name but are not expanded on or explored. The plan offers design and location options for components such as street and boulevard trees and pavers but none for luminaires." (Paskovic, 2012) (Vancouver, 2007)

Figures below (Fig 52, 53) show position of the site in Vancouver city and aerial view of this area. Figure 54 indicates existing lighting condition and luminaries types in this site.

Figure 52: Position of Southeast False Creek in Vancouver city. Source: bcwireless.net/moin.cgi/VancouverMaps

Figure 51: Aerial view of area.Source: VanMap onilne.

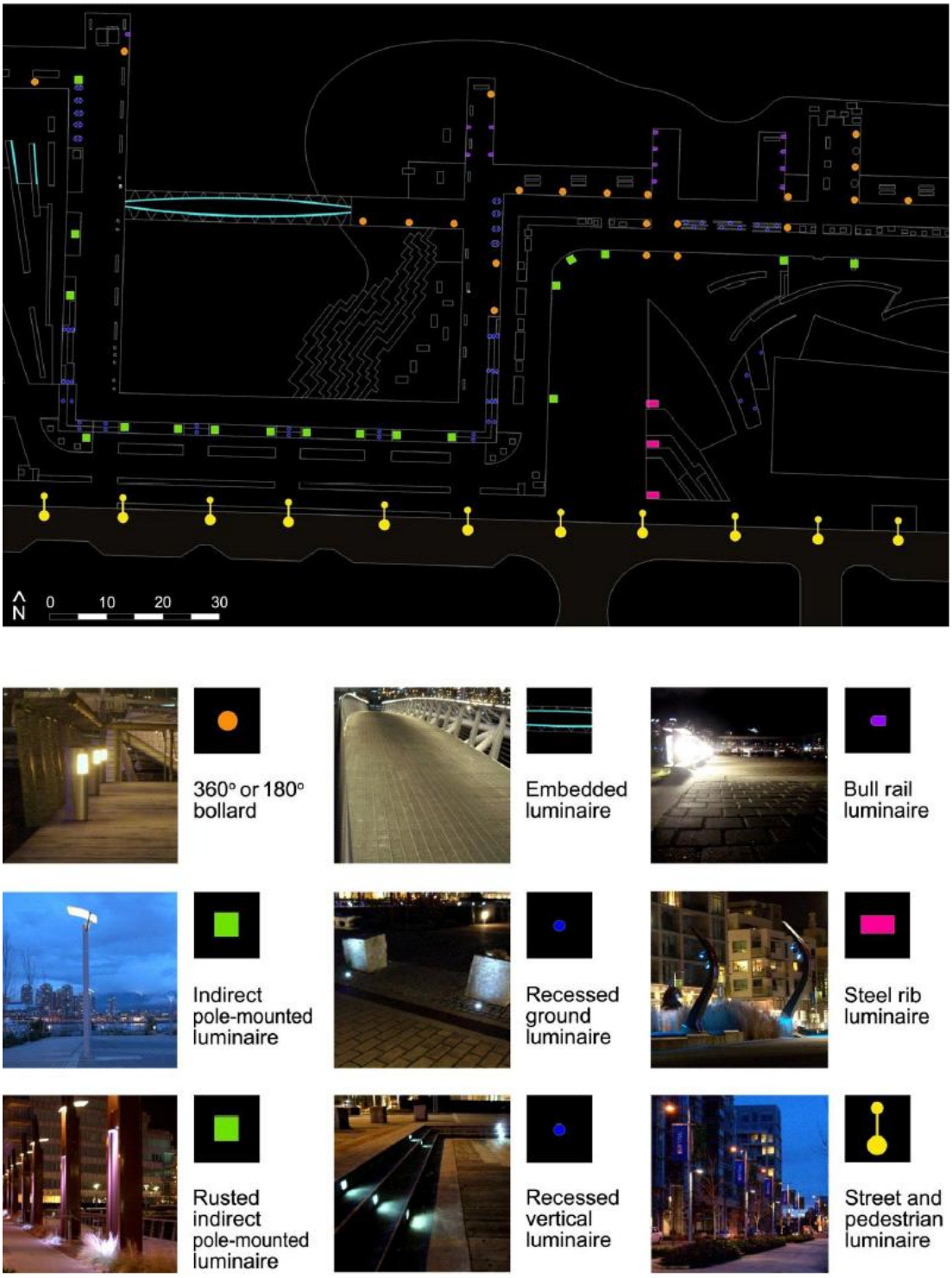


Figure 53: existing lighting condition and luminaire map. Source: Anya Paskovic, 2012

Urban lighting of this region, rather than starting from a lighting master plan, is achieved by set of singular lighting projects. This approach to urban lighting, since divides the lighting plan to minor projects, increases the feasibility but also increases

the risk of remaining un-illuminated spaces or may lead to a disharmonious nocturnal layout.

5.3.1 Pedestrian and Cycle Routes

The majority of luminaires of pedestrian and cycle routes are white light emitting metal halide or LED lamps, however for streetlights (car accesses), high-pressure sodium lamps have been used that produce an amber glow which is common to most of the City's public streets.

Within this area steel rib luminaires with their unusual form attract the most interest of all the luminaire types. The changing colours of LED sources draw people towards the plaza and make people to stop and look up towards the luminaires. (Fig 55) "Some patrons were observed waiting for the lights to change colour. Children in particular, were drawn to these luminaires, and would play within the streams of light." (Paskovic, 2012)

Figure 54: steel rib luminaries. Photo credit: Unknown

As Analysis of existing lighting condition of two sections of this region (shipyard plaza and promenade) by A. Paskovic shows some parts such as cycle roots had been left un-illuminated. (Fig 56) As result it can be stated that in similar conditions which starting from a lighting master plan is not feasible, conformation of singular projects with the lighting master plan is of a great importance.

Figure 55: Cycle route left unilluminated intervenes with pedestrian access. Photo credit: Paskovic 2012

5.4 Conclusion

In chapter five main objectives of two L.M.P has been reviewed. In the first example which was ‘Lyon’, the main concept was to emphasize on historical character of the city and consolidate the city's position as a leader in lighting design. To achieve this goal several sites in large-scale were illuminated and a special attention was paid to emphasize on specific characteristics of the city such as bridges, historical districts and parks. Also it can be stated that the first L.M.P of Lyon which had been applied to the city in 1989, met the basic needs of city related to lighting and provided a background to pay attention to more aesthetical points of view in the second L.M.P in 2004. ‘Stuttgart’ case elaborated an example of applying L.M.P to a specific district to solve functional shortcomings. In conclusion review of these examples provided better understanding of applying a lighting master plan by considering limitations and possibilities of each district or city.

A very important issue which has not been mentioned in related documents of any of these L.M.Ps is cultural, geographical and climatic variations and possible reflections these factors may have in a L.M.P. For instance serious daylight condition differences between scandinavian climate and hot and dry climates would most probably affect expectations of city dwellers from artificial lighting.

Chapter 6

CASE STUDY ANALYSIS AND SUGGESTIONS – CASE OF FAMAGUSTA WALLED CITY

6.1 Introduction

In conclusion this study aims to formalize and define a common ground for evaluation of Lighting Master Plans. Considering literature review, research defines 13 factors divided into 3 categories as a basis to examine current lighting circumstances of 'Walled City of Famagusta' as case study. Afterward solutions have been suggested for the improvement of existing lighting of 'Walled City'.

1- Public's comfort

- Visibility
- Glare prevention
- Color rendering index (CRI)
- Patron group – Public Health
- Smart lighting

2- City Image (Lynch's theory)

- -Paths
- -Edges
- -Districts
- -Nodes
- -Landmarks

3- Lighting design principles (Kelly's theory)

- -Ambient luminescence
- -Focal glow
- -Play of brilliants

6.2 Case Study Analysis

Walled city in Famagusta,(fig 57) which once was the Famagusta City itself, is now a small part of the enlarged modern city of Famagusta. The Walled City is the main tourist attraction of Famagusta. Lighting analysis and a lighting master plan for the whole Walled City needs a rather broad investigation which cannot be satisfactorily carried out in a master thesis. Therefore, current research has been narrowed and focused lighting for touristic purposes within the Walled City, including vehicle accesses, pedestrian paths, and tourist attractions. In order to evaluate urban lighting of the Walled City and to be able to go further and suggest a lighting master plan for this small city, above mentioned factors have been evaluated as a basis to be able to

examine the existing lighting and to provide a guideline for the new lighting master plan.

The picture below shows the aerial view of Famagusta's Walled City (Fig57) located in the south east section of Famagusta beside the Mediterranean Sea. In order to be able to analyze existing constraints of the Walled City, this survey begins with an analysis of the patron groups and residents of this area and continues with an evaluation of overall illumination and lighting conditions of the main urban sections, such as paths, entrances, surrounding walls and overall view of Walled City from outside.

Figure 56: Aerial view of Walled City of Famagusta (source: map.google.com)

6.2.1 Existing Constraints

6.2.1.1 Patron Group

Patrons of Walled City can be divided to three categories; tourists, residents and students. Although the research focuses on the touristic attractions of Walled City, the Lighting Master Plan requires considering all three mentioned patron groups. Considering the majority of patrons which are adults and elderly tourists and residents (50-80 years old), visibility of surfaces and happenings in ground level such as steps, level differences and ramps are very important. Also recognizable routes and well defined illuminated junctions improves orientation, therefore increases independence use of space for elderlies. There were very few childs observed in the area. The main young patrons are students who are temporary residents of Famagusta. Most pther students mainly visit this site at weekends or during special events. Considering policies to absorb more young people during the week will help enriching the age pyramid of Walled City users.

Another important issue is current residents of Walled City, poorly designed lighting strategies can negatively impact natural habitats and be viewed as an annoyance by neighboring residents and patrons of lit public spaces. The Walled City is consist of a rich mixture of different functions including residential areas. Preservation and revival of residential areas is of a great importance in this site. Considering lighting strategies which are friendly for habitats while provide main expectations of public lighting is an objective of Walled City's lighting plan.

Figure58 depicts existing position of residential blocks, pathways and main touristic zone within the Walled City.

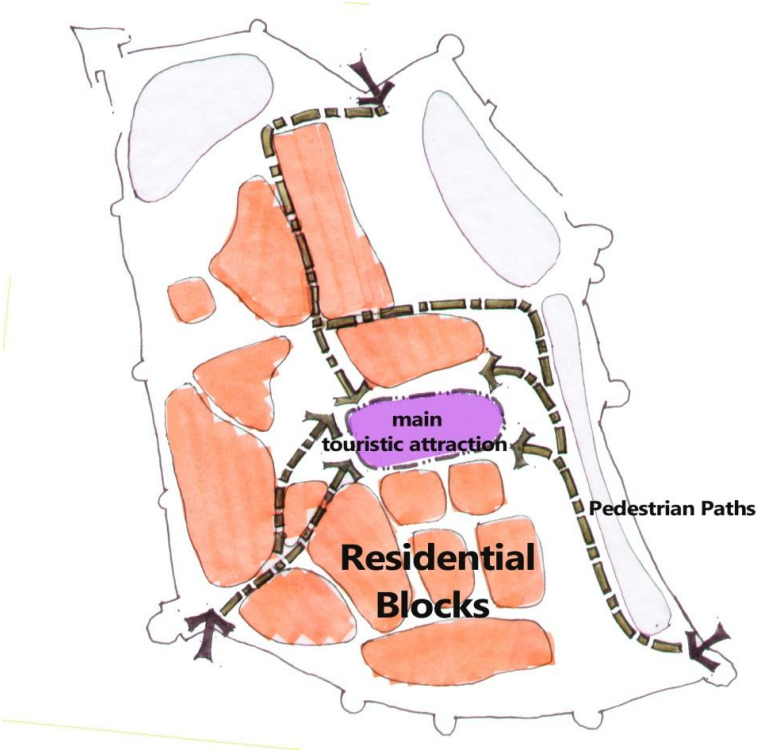


Figure 57: Touristic pathway located among residential blocks in Walled City.

As can be seen in the illustration above the touristic pathways are strongly interwined with residential blocks. In order to design appropriate lighting for these paths two issues should be considered, first; precious selection of height and form of light sources to avoid light trespass through houses' windows. Second; avoiding use of occupant detector smart in paths adjacent to residential units. Although occupant detector sensors save large amount of energy, nevertheless inappropriate use of this technology may cause annoying effect of light changes for neighborhoods.

6.2.1.2 Considerations for Lighting in an Old Town

Preservation of heritages is a critical issue nowadays. There is a fact that there might be hidden values in a historic building or site that we do not know now. Considering this concept preservation of historic sites for further analyzes in the future is of a great importance. This approach is not only valuable for architecture but also from urban design and lighting design point of view. "How much more mysterious and

inviting is the street of an old town with its alternating realms of darkness and light than are the brightly and evenly lit streets of today!" (Pallasmaa, 2005) This critical perspective to overly illuminated modern spaces can also be seen in the works of a British photographer 'Dan Holdsworth'. In his photos urban spaces are more like a part of an abandoned city, extremely illuminated with no people using it.

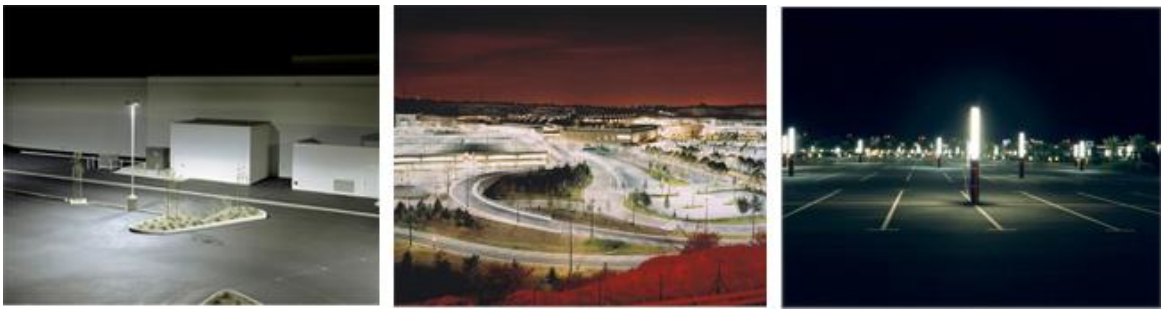


Figure 58: Urban spaces are empty of people but full of light in Holdsworth photos. Photo credit: Dan Holdsworth Danholdsworth.com

If artificial lighting had already transformed all old towns to "bright and evenly lit" spaces, we would never be able to experience the "mysterious and inviting streets of an old town". The author suggests preservation of one or part of a street and one building within the Walled City with the existing luminaries and light sources to be considered in the L.M.P. Selection of mentioned street and building can be judged by comparison of their current lighting condition with defined requirements in the L.M.P.

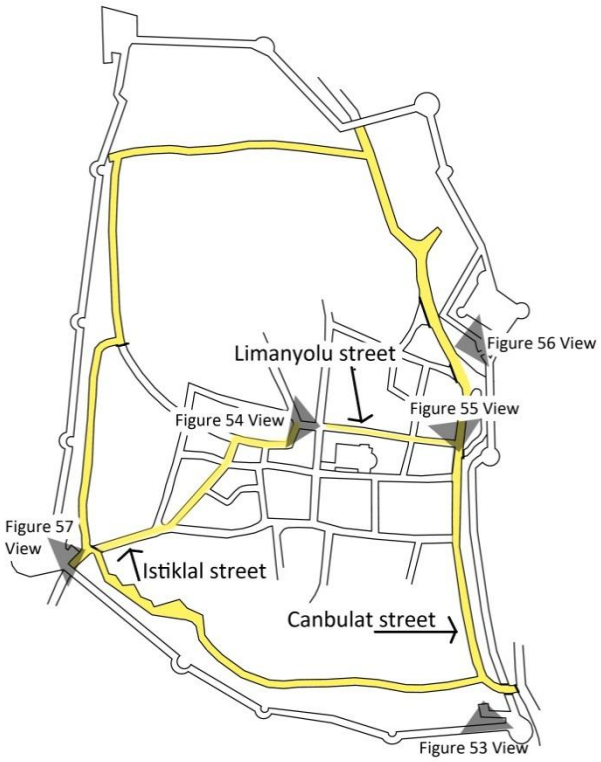
Pallasmaa in his book 'The Eyes of The Skin' (2005) reminds us of the importance of the involvement of all the senses including touch and hearing in experiencing an architectural space. "Our skin traces temperature spaces with unerring precision; the cool and invigorating shadow under a tree, or the caressing sphere of warmth in a spot of sun, turn into experience of space and place" (pllasmaa, 2005) So a complete

experience of a space requires involvement of more senses rather than only vision, to invite people to meet historical buildings more subjectively as their other senses will also be affected by experiencing the echo of the building, the harshness or softness of materials and the penetration of light from openings.

6.2.1.3 Evaluation of User's Comfort

6.2.1.3.1 Visibility

Although providing visibility is one of the primary expectations which is mostly provided by street lights, un-balanced distribution of light posts had left numerous dim paths and spaces in the walled city. Figures 60 and 61 show the contrast between over illuminated 'Canbulat Street' and 'Limanyolu Street' which provides the access to Namik Kemal plaza and is absolutely dark during the night.



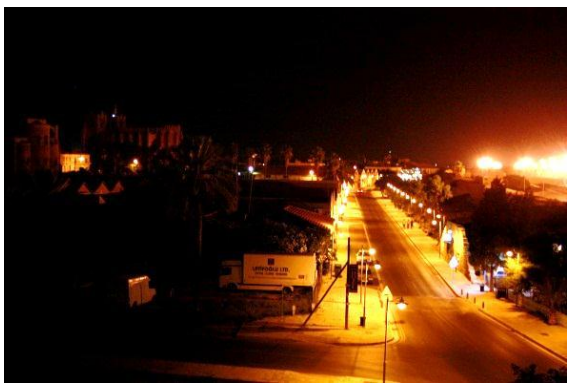


Figure 59: Bird view of Canbulat Street. More than 35 lamp posts are implanted in this street. (photo by author)

Figure 60: The left side of this figure is Limanyolu Street which is completely dark. (Photo by Author)

6.2.1.3.2 Glare Prevention

Light sources can be categorized into three main groups; street light posts, pedestrian paths light posts and historical buildings lighting. Most of street lights are high-mounted lamp sources, covered with spherical cover which diffuses light and minimizes the emission of light beams close to eye level. (fig62) The important issue about street lights is that, since historical buildings are one of the main touristic attractions of this site, when these lights are placed in front of a building which has more height than the lamp post glare occurs. (fig63) The pedestrian path's lamp posts and lighting of historical buildings do not have glare problem.

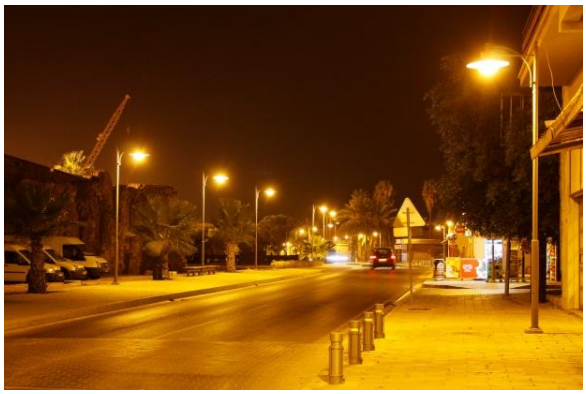


Figure 61: Spherical light bulbs diffuses the light in Canbulat street. (Photo by Author)

Figure 62: High mounted street lamp causes glare effect in front of high historical building. (Photo by Author)

6.2.1.3.3 Color Rendering Index (CRI)

Light sources used as street lights, as well as most of light sources in the Walled City, are High-pressure sodium lamps which have a low level of color rendering index (CRI=24). This issue is the reason the whole street is in a saturated red-yellowish color causing very low level of color recognition.(fig64) As discussed before in chapter 3, low level of CRI causes distortion in recognition of colors and eventually decreases the level of comfort for visitors.

Figure 63: High pressure sodium lamps used for street lighting makes a saturated yellowish light with low level of CRI. (Photo by Author)

6.2.1.3.4 Public Health

High-pressure sodium lamps and mercury vapor lamps have been used for both street lights and pedestrian lights which contain noxious substances. Inhaling mercury or mercury compounds in vapor or powder form or touching a broken mercury lamp can lead to serious health problems since mercury can also be absorbed through the skin. These light sources had been categorized as hazardous waste which is harmful for both environment and people.

6.2.1.3.5 Smart Lighting

Smart and intelligent lighting has not been implanted in any of current lighting devices of walled city. Smart lighting can be achieved by adding smart kit devices to existing lamp posts. The smart kit detects the presence of users and raises the illumination from 20% to 100%. Great amount of money will be saved by this technology which can be invested for the illumination of other parts of the Walled-City.

6.2.2 City Image (Lynch's Theory)

Considering Lynch's theory, by providing these five factors; Paths, Edges, Districts, Nodes and Landmarks, people will be able to understand the layout of a place. This increases legibility (addressing) and therefore brings comfort to the users by giving them basic information about the surrounding space.

6.2.2.1 Paths (Vehicle Accesses and Walkways)

The main vehicle access in Walled City is circular road which also provides the access to the main touristic point; Namik Kemal square, by a street. This path is partially illuminated and does not provide a definable path for visitors. The Walled city contains an organic shaped network of walkways. 'Istkilal' street is the most active path in this site, provides pedestrian access from one of the entrances to

Namik Kemal square. This path is illuminated with light posts which have a harmonious shape with the surroundings (fig 65), however the whole pathway is not illuminated clearly and visitors may lose the main track at the first or second junction.

Figure 64: Lamp posts in pedestrian accesses - Istiklal street

6.2.2.2 Edges

Active edges of 'Istiklal' Street and Namik Kemal Square and the surrounding historical wall are the main edges of this site. Lighting of retails, eateries define the urban edges within the site during their open hours, but the surrounding wall is mostly left dim except for some parts.

6.2.2.3 Nodes and Landmarks (Historic Buildings, Notable Architecture)

Since the network of accesses is mainly consists of organic paths, nodes are of a great importance in this site. Emphasize on nodes helps visitors find their way easier. Some of main nodes such as entrances of Istiklal Street and Namik Kemal Square are in a good condition in terms of public lighting, however, three entrances if Walled city and pathway's junctions are not well identified.

The landmarks of this site are the most important elements among Lynch's factors. The Walled city includes numerous historic buildings left un-illuminated. The most important historical site of Walled City includes significant landmarks such as; 'Lala Mustafa Pasa Mosque', 'Remains of Venetian Royal Palace', 'Famagusta Medrese Religious House' and 'Saint Peter and Saint Paul Cathedral'. These buildings together with the open urban space of 'Namik Kemal Plaza' surrounded by cafes, bars and eateries act as the heart of Walled City which hosts numerous tourists and social activities every year. 'Lala Mustafa Pasa mosque' is one of few buildings which is still in use as a religious space. Lighting of main façade of this building is provided by two halide metal lamps implanted in the pavement in front of the building (fig66). Color rendering index of these lamps are high (75-85 degrees) which gives good color recognition for its function. Although the illumination does not cover the whole façade and gradually fades along the façade, but the angle of emitting light (65 - 70 degrees) creates a unique play of light and shadow by emphasizing rich prominent motifs of the facade. The main problem with the lighting of the main façade is that one-third of it from the ground level up to almost 3 meters height is always dark. Side facades and the back side façade of this building are not well illuminated; they are visible by street lights and downward flood lights in the backyard (fig67). As a result the surroundings is more lit than the building. There are several paths, buildings and sites around and near to Namik Kemal plaza, which are not illuminated but are highly potential for lighting design. Remains of Venetian Royal Palace and Namik Kemal Prison together create a semi open space located in the main touristic site of walled city; Nami Kemal Plaza and also defines one of the edges of this plaza by a Venetian period vault (fig 68). Various events take place in 'Namik Kemal Prison' every year, such as, music festivals, international dance

shows and the New Year celebrations. Beside the especial event's period, the semi-open space of this site is in a very poor lighting condition. The only illuminated part is the arched wall which also defines the entrance of this historic site. (fig 69)

Figure 65: Venetian Vault

Figure 66: Day view of Semi open space – Namik Kemal Prison and Remains of Royal Venetian Palace

Figure 67: Side facades and back facade of the most important touristic building in the site are not illuminated.

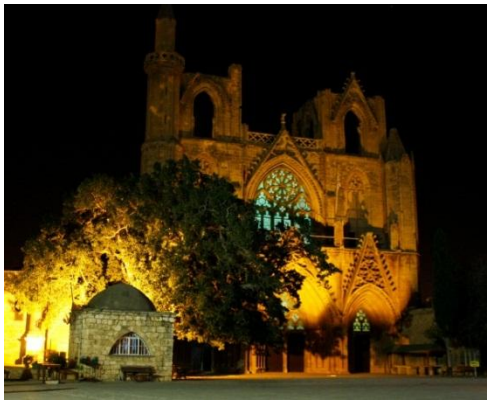


Figure 68: Saint Nicholas Cathedral (Lala Mustafa Pasa mosque) - main facade

6.2.3 Lighting Design Principles (Kelly's theory)

The first factor in Kelly's theory is Ambient Luminescence which provides visibility, security and continuity of vision and allows visitors to experience sequences of the space as a part of whole. The second factor (Focal glow) directs the attention to an important object, event or happening which helps the orientation, and the third factor (Play of brilliant) is the 'meaning' giving factor where the main character of the scene has to provide a unique and differentiable experience which belongs to that specific space. The Walled city's lighting provides the first factor in Istiklal Street,

Namik Kemal Plaza and in eastern zone with street lighting and lighting of eateries' such as 'Petek Pastahanesi'. Focal Glow in Walled City mainly draws the attention to eateries and retails. However, appropriate focus on historical buildings which are the main potentials of the site is currently in a very poor condition. The third principle (The play of brilliant) is completely missing. An artistic lighting, designed specifically for a building or a site, lighting installations or a video mapping with a relevant concept to the historical context can provide the Play of brilliant and emphasize on unique character of Walled City.

6.3 Conclusion

This study performed an analytical investigation on the characteristics of lighting which had been applied to the case study – Famagusta walled city – and, shortcomings were identified. Compared to key elements of the lighting master plan which were analyzed throughout this research, the lighting design of the case study for Walled City could be improved and proper lighting master plan is proposed. Figure 70 shows a schematic view of Walled City's lighting master plan follows by deeper investigation of each layer.

Figure 69: schematic view of Walled City's lighting master plan

-The whole city was once surrounded by a water ditch and a thick high wall which is still preserved in a good condition. The exterior side of wall together with the water

ditch defines the physical and visual boundaries of Walled City during the day, nevertheless, due to the lack of appropriate lighting these boundaries are not clearly visible at night. Since illuminating the whole lengths of the wall is not necessary and needs high primary costs, illumination of three entrances and adjacent walls is suggested. Also illumination of the water ditch around the entrances with vivid blue lights can complete the lighting scenario by bringing back the memory of water to the ditch and eventually to people's mind. Entrances could be emphasized and differentiated by the color of lights; yellow, white and red floodlight LED. Also the ditch can be illuminated with low level mounted LED lights. Mercury-free upward florescent lamps are suggested for lighting of exterior walls. Entrances and the water ditch are located in figure 71. Also the expected result can be seen in figure 72.

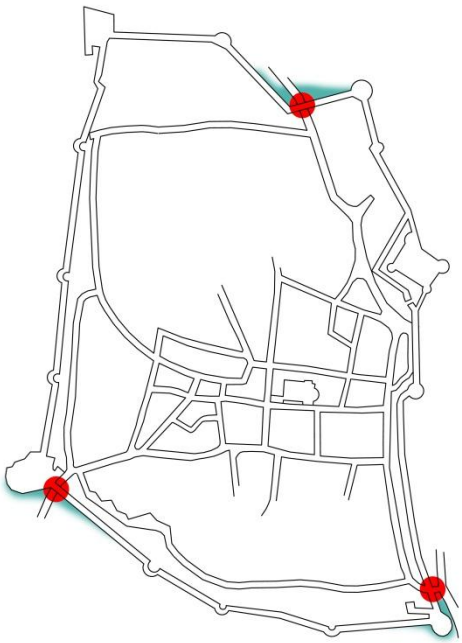


Figure 70: Location of Walled City's entrances and the surrounding water ditch

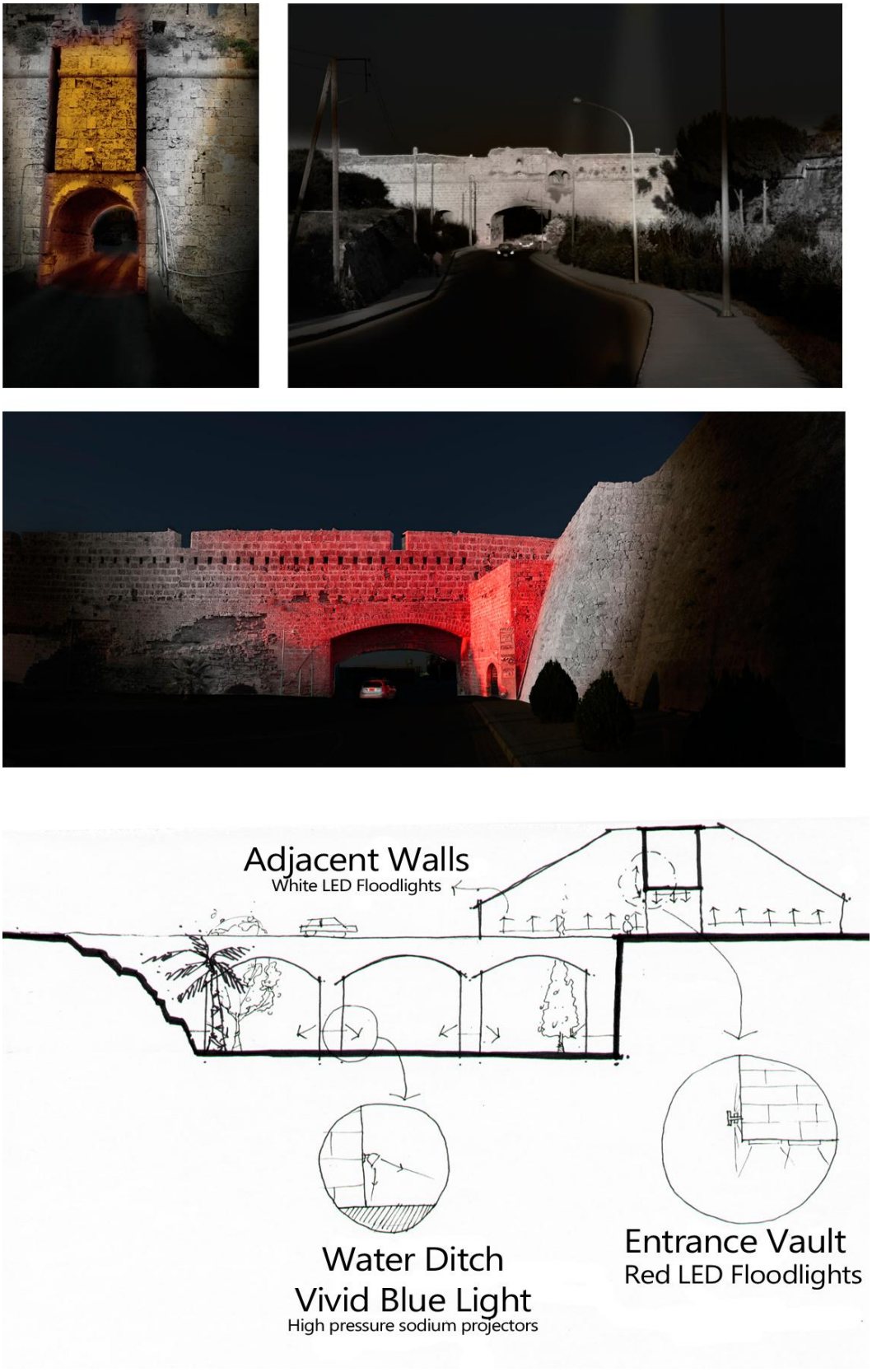


Figure 71: proposed lighting scheme for entrances of walled city

- Installation of yellow emitting LED lamp posts equipped with smart occupant detector for the vehicle access ring is suggested. Smart kits can also be implanted to

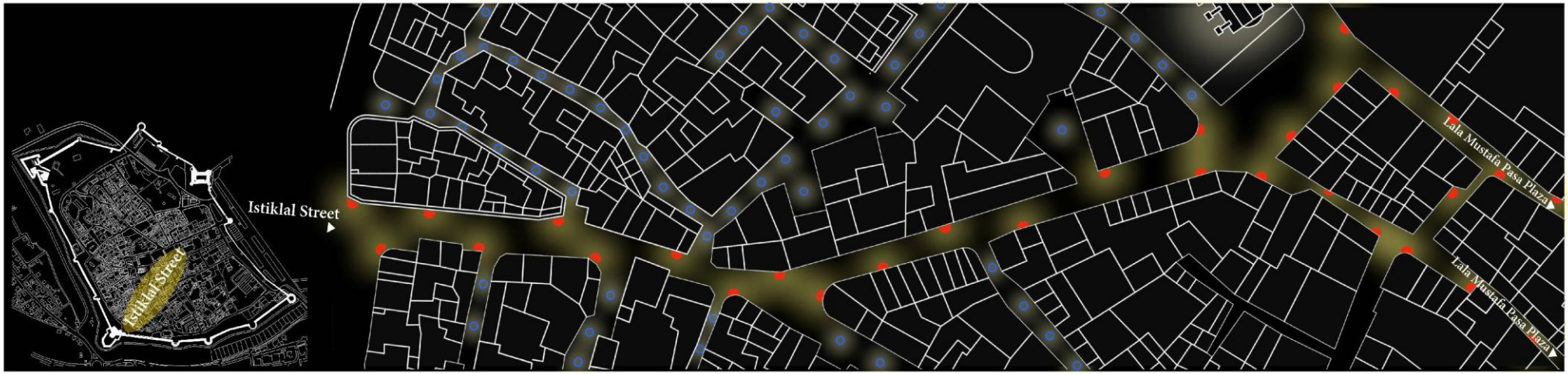
the existing lamp posts. Smart grid reduces energy consumption by providing light when and where it is needed. In this system lamps are connected together and also to control center and inform the center about the condition of lamps, therefore reduces maintenance costs as well. Figure 73 shows suggested vehicle access within the Walled City.

Figure 72: Main vehicle access ring

- Illumination of pedestrian accesses with LED lamps is suggested to provide pedestrian circulation and connect important landmarks. Using white and vivid yellow colored LEDs will make contrast between paths and yellow colored lighting of historical buildings. LED is a mercury-free lamp, have long life of almost 100,000 hours and provides high level of color rendering (CRI 80-95) which makes it a suitable choice for pedestrian. LEDs are also suitable for providing a comfortable “Ambient luminescence” since they emit diffused and

soft light. (fig 74). Illustration in Figure 75 is prototype lighting for Istiklal Street, Lala Mustafa Pasa plaza, Saint Nicholas Cathedral and Limanyolu Street. As it can be seen in suggested lighting technics and relative fixtures, the main touristic pathway is equipped with smart lighting while adjacent pathways within the residential blocks are normal downward luminaires.

Figure 73: Pedestrian pathway network



Pedestrian Pathway Luminaires
Equipped with smart lighting kit
Light source: Warm white LED

Residential Pathway Luminaires
Light Source: White LED or Mercury free SFL

Seperator Pillars
360 degree bollard
Light source: Warm white LED

Greenery Lighting
Projector
Light source: White- Blue LED

Steps Lighting
Recessed Vertical Luminare
Light source: Warm white LED

Architectural Lighting
Flood Light & WallWasher LED
Light source: Warm white - Yellow LED

Parking Lighting
Indirect Pole Mounted Luminare
Light source: white LED

Historical buildings are the most attractive potential of Walled City. Many of these valued buildings such as church of St. George, Othello Tower, Twin Churches are in very poor lighting conditions. The author suggests re-illumination of historic sites with a focus on yellow emitting light sources which matches with the colors of materials used in most of these buildings and reflects their daytime character. Figure 76 shows distribution of important historical buidlings in the main touristic zone of Walled City.

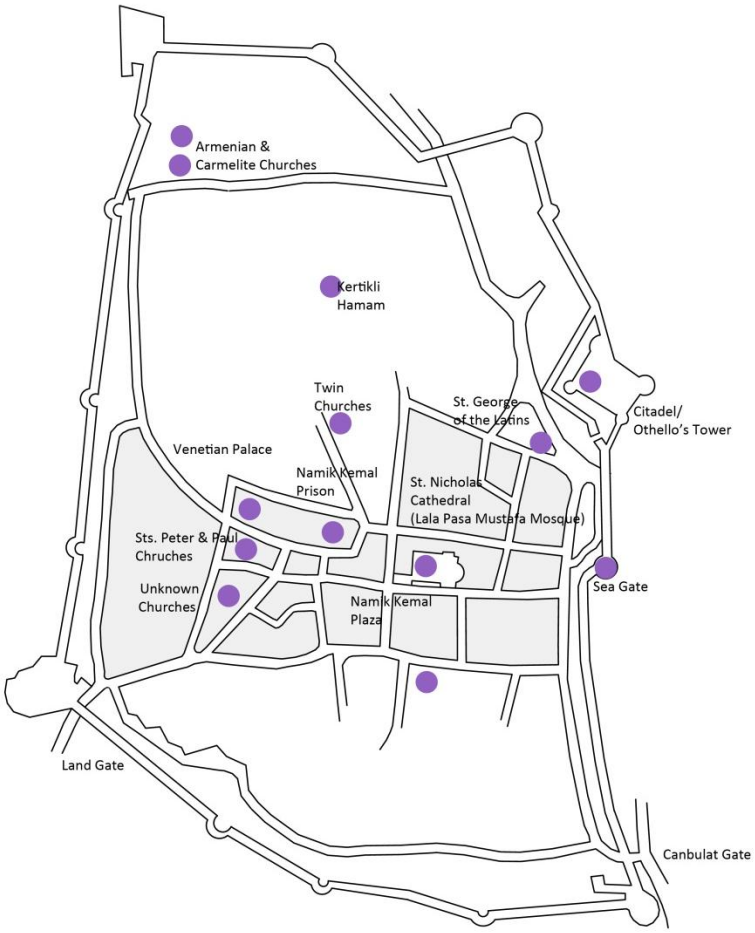


Figure 74: Distribution of important landmark within the researched area

- Namik Kemal Prison: Rather than a small café which is usually closed at night no other functions are regularly taking place, in big semi open space of Namik Kemal Prison. It seems that illumination may not succeed in absorbing people unless the lighting plan also provides compatible functions for this site to

involve visitors with the site. The research suggests a transformation of the whole site into a ‘Smart Urban Space’ via providing following features;

- Installation of smart occupant detector equipped lamp posts in order to provide visibility during the night.
- Monthly visual arts exhibition to be projected on remaining walls of the palace. (fig77)
- Wireless internet for the use of public
- Interactive touristic information point where group of people can see the touristic map of Walled City, share information, discuss subjects and get directions for their visit on a big projected screen. (fig78)

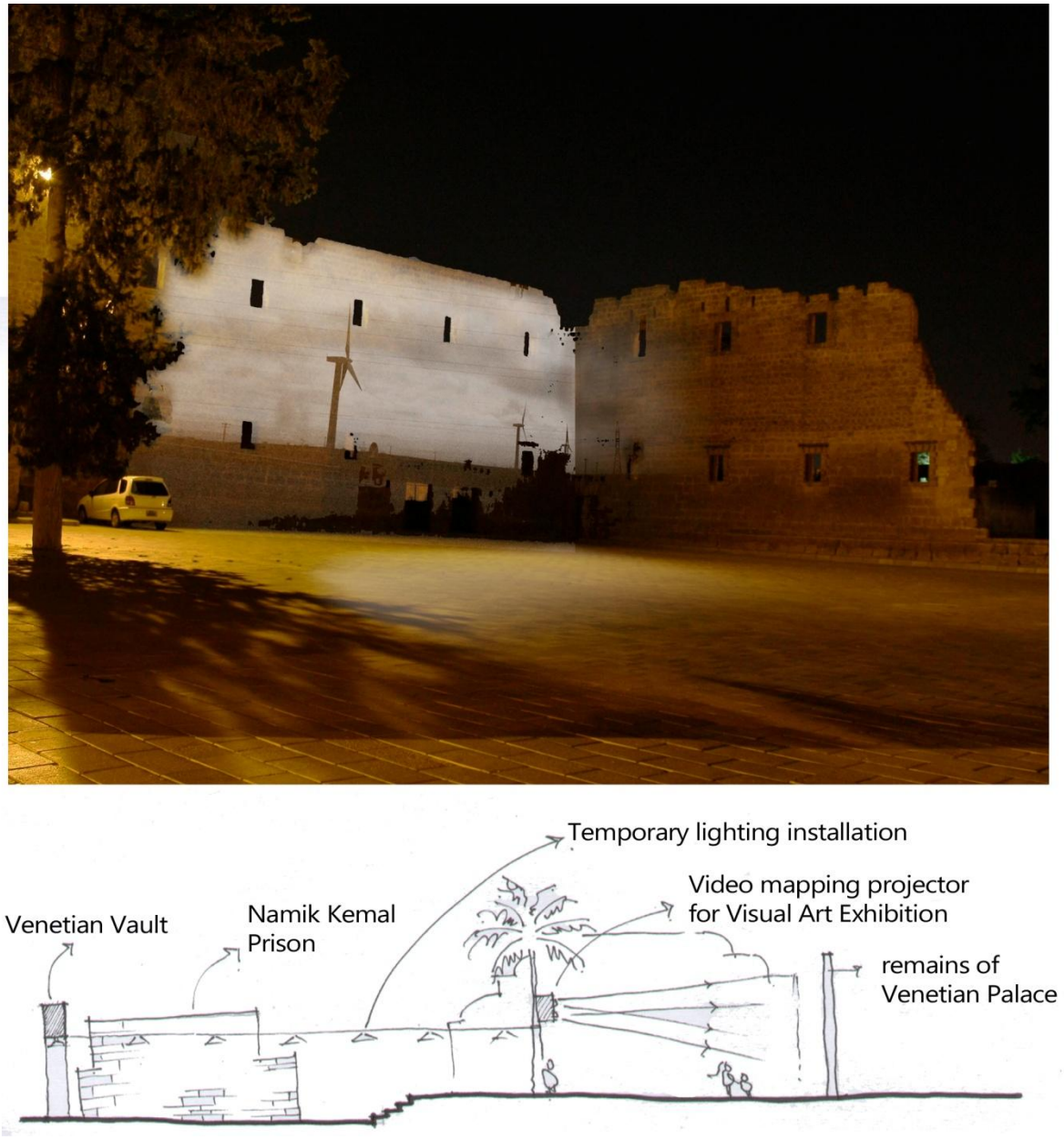


Figure 75: Exhibition section provided by projected visual art illustrations on remaining walls of Royal Palace

Figure 76: Interactive Information point in the Smart zone of Namik Kemal plaza

Othello Tower and Sea Gate: The Sea Gate is semi-active landmark during the night where many visitors climb the stairs of it to experience a different view of Walled City from a high level. Both buildings are completely dark at night. Rather than one high pressure sodium lamp which illuminates a part of Othello Tower there are not any other light sources for illumination of these buildings. Since these two buildings are located in the same area and rather than a small sign which is hardly visible at night no other information is available, most visitors get confused and consider Sea Gate as Othello Tower. Re-illumination of both buildings with mixture of yellow and white LEDs will make this important touristic zone legible. Special attention has to be paid for illumination of Othello Tower. William Shakespeare had written his famous novel ‘Othello’ while he had been staying in this building and the story of the novel happens in the same building. Lighting installations such as projection of illustrations, texts and videos related to this important building can reflect the great

history behind it and play a great role in attracting people to visit Walled City of Famagusta.

Figure 79 is a schematic view of lighting suggestions for these two buildings.

Figure 80 illustrates expected result of projecting a part of Othello drama on the façade of Othello Tower.

Figure 77: Schematic lighting suggestions for Othello tower (top) and Sea Gate (bottom)

Figure 78: Projection of Othello drama on the facade of Othello Tower

- Since St. Nicholas Cathedral (lala Mustafa Pasa Mosque) is visible from several areas in Famagusta city, as the tallest building of Walled City. Proper lighting can make this building as the main visible landmark during the night and facilitate orientation.(Fig 81) Temporary lighting installations for special events and

happenings such as programmed light changes and video mapping projection will surely transform this building to the ‘Play of brilliant’ of this site and act as visual announcement for happenings and events of Walled City which is also visible from outside. This will eventually arouse the interest of both residents and visitors of Famagusta to visit this site. (Fig 82, 83)

Figure 79: Proper lighting transforms Saint Nicholas Cathedral to the main visible landmark during the night as well as it's main character during the day and facilitate orientation.

Figure 80: Temporary lighting installations as announcing a special event or happeningExpected result

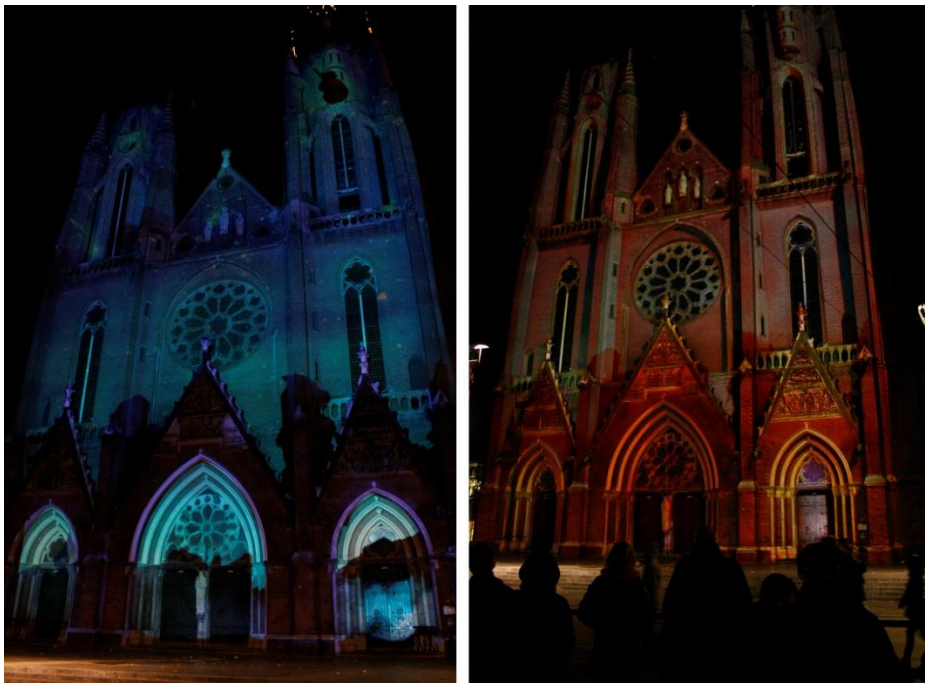


Figure 81: Video Mapping technic can provide a complete new night life for a historical building. St Catharina Cathedral during 'Glow' Lighting Festival 2012 - Eindhoven, Netherlands

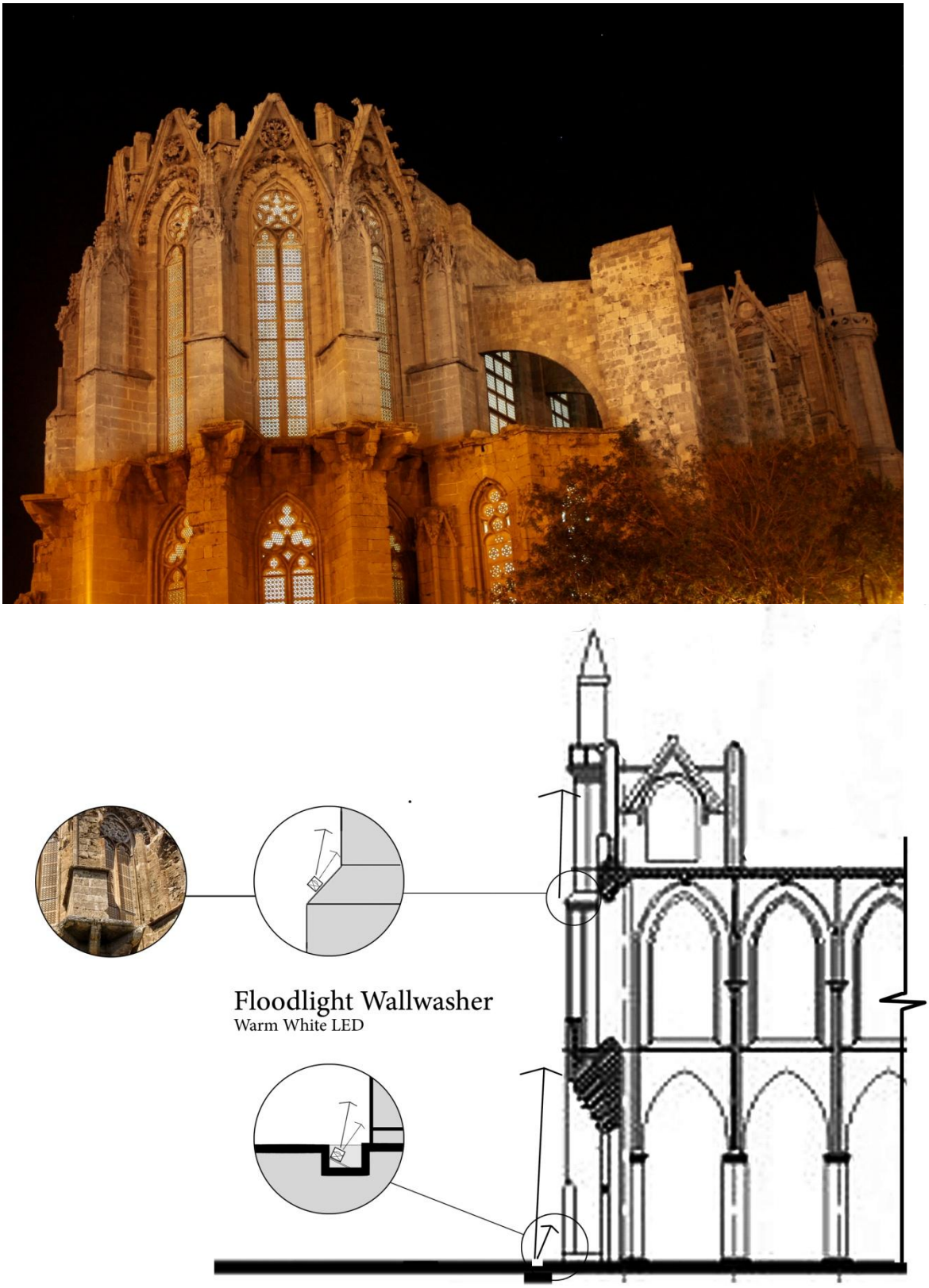


Figure 82: Proposed facade lighting, expected result and details for Saint Nicholas Cathedral

Figure 85 is Walled City's lighting master plan achieved by conformation of above mentioned factors.

Figure 83: Suggested lighting plan - Walled City Famagusta

Chapter 7

CONCLUSION

Lighting master plan has to provide a creative nightscape which is supposed to be dıfferent from the day-view, and while provides safety creates more poetic, more mysterious and maybe more colorful world of night where numerous light sources unify the night-face of the city in a democratic way rather than the dictatorship of the Sun in the day. The key point is that Lighting Master Plan is also responsible to ensure the optimum of being different while still recognizable so people would feel the difference yet not get confused. This is achievable by considering Lynch's Image of The City factors. By providing common key elements and reflecting their day view character at night, legibility and recognizability of urban spaces can be achieved.

In conclusion it can be stated that for bringing back people to urban public spaces appropriate lighting has to provide a pleasant background for emerge and growth of other activities. Also lighting itself can be the main attraction of a public space by using new technologies such as lighting installations and video-mapping. The main result of this dissertation is that in order to bring back people to public spaces via lighting, a lighting master plan to ensure the success of related lighting designs in a city is necessary.

According to the results of the survey current lighting condition of Famagusta's Walled City needs a complete revision. Several benefits will be achieved by applying the suggested lighting master plan such as; increasing legibility and arousing interest between tourists and residents of Famagusta to visit this site and moreover to spend their spare time and socialize in this valuable historical site. Moreover a comprehensive lighting of important landmarks within this site introduces hidden values of this site to the people and increases public awareness about valuable potentials of Walled City and therefore absorbs investments for further improvements. Above mentioned advantages boosts the identity of city and invites new range of visitors who may not be aware of this historical site.

It seems that installation of smart lighting kit to the existing lamp posts can be the starting point if the lighting master plan since it decreases energy consumption while provides light when and where it is needed. Therefore the money which will be saved this way increases the possibility of installing new lighting fixtures.

7.1 Recommendation for further research

Since the city of Famagusta also faces serious shortcomings related to lighting in public urban spaces, Resulting findings could be applied to street and public spaces of Famagusta following the guidelines of recommended lighting master plan. Author suggests lighting master plan of Famagusta for further researches considering possible future of LEDs and smart lighting system.

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