Achieving the Positive Impacts of Light by Means of the Smart Lighting

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ABSTRACT

Light has always been an important issue for human, especially after invention of the electrical light bulbs, which open a gate to a new kind of technology. Therefore, that in today's world using the light in a smart manner and to benefit from the lighting is a new field for many studies.

Light and lighting play a very important role in different places and spaces for the need and tasks of users. Designing the smart lighting systems in order to make the technology organizing the lighting according to the situation can be very beneficial for both the architect and user.

Also due to the known negative impacts of the improper kind of lighting, and the necessity of the lighting in almost every space, many studies have been conducted about lighting. Although lots of information and research has been done also on the smart lighting, the lack of information clearly known related to the designer (architecture). In order to achieve this task, information and data related to light, lighting and smart lighting is collected and analyzed. Thereby the study is based on the literature review over the light and artificial light natures and their impacts on energy consumption and human from the psychological and physiological points of view. Also the examples from the international companies, is reviewed to reach the conclusion.

It also should be mentioned that the study is based on the qualitative enriched by the quantitative methods.

Finally, the results reveal that the smart lighting has the potential to be used by the architects and users to fulfil the positive impacts of the light from the energy cost reduction in the buildings and improve the human health.

Keywords: Smart Lighting, Light, Energy Consumption, Human Health

ÖZ

Işık insanlık için her zaman önemli bir olgu olmuştur. Özellikle yeni bir tür teknolojiye kapı açan ampullerin icadından sonra daha da önem kazanmıştır. Bu nedenle, bugünün dünyasında ışığı akıllıca kullanma ve ışıktan faydalanma konuları birçok çalışma için yeni bir alan yaratmıştır.

Işık ve aydınlatma, kullanıcıların ihtiyaç için farklı yer ve alanlarda çok önemli bir rol oynar. Her koşula göre aydınlatma tasarımının düzenlenmesi için akıllı aydınlatma sistemlerinin tasarlanması hem mimar hem de kullanıcı için çok faydalı olabilir.

Yanlış aydınlatma türünün bilinen olumsuz etkileri ve neredeyse her alanda aydınlatmanın gerekliliği nedeniyle aydınlatma konusunda birçok çalışma yapılmıştır. Akıllı aydınlatma konusunda çok sayıda bilgi bulunsa ve araştırma yapılmış olsa da tasarım (mimarlık) ile ilgili açıkça bilinen bilgilerin eksikliği söz konusudur. Bu araştırmanın gerçekleşmesi için ışık, aydınlatma ve akıllı aydınlatma ile ilgili bilgi ve veriler toplanmış ve analiz edilmiştir. Bu nedenle, çalışmanın temelinde ışık ve yapay ışık niteliklerine ilişkin literatür taraması, bunların enerji tüketimi ve insan üzerindeki psikolojik ve fizyolojik etkilerini yer almaktadır. Ayrıca, uluslararası firmalardan örnekler sonuca ulaşmak için incelenmiştir.

Aynı zamanda, çalışmanın temelini niteliksel yöntem oluşturmakta olup niceliksel yöntem ile de zenginleştirilmiş olduğunu belirtmek gerekmektedir.

Son olarak, sonuçlar akıllı aydınlatmanın mimarlar ve kullanıcılar tarafından binalardaki enerji maliyetinin düşürülmesi ve insan sağlığını iyileştirmek gibi olumlu etkileri için kullanılma potansiyeline sahip olduğunu göstermektedir.

Anahtar Kelimeler: Akıllı Aydınlatma, Işık, Enerji Tüketimi, İnsan Sağlığı

I dedicate this thesis to my family who have always had faith in me and supported finalization of this work in every possible way.

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Chapter 1

INTRODUCTION

After the discovery of fire by human being, the initial type of artificial lighting utilized to illuminate a location had been campfires or torches. As the first time as 400000 BCE, fire had been kindled in the caves of Peking human being. Prehistoric people utilized elementary oil lights to illuminate environment. These kinds of lights had been created from naturally occurring components for example small stones, shells, animal horns and tocks, had been loaded with grease, and acquired a fiber wick. Lights in general used animal or plant fat and oil as energy resource. A huge number of these lights (hollow worked stones) have already been discovered in the Lascaux caves in modern- time France, has been dated around 15000 years back. Fatty animals (birds and sea creatures) were even utilized as lights after getting threaded with a wick. Fireflies have already been used as light resources. Candles and glass and pottery lights were even created. Chandeliers were the first type of "light fixture".

A significant decrease in the expense of lighting happened due to the finding of whale fat. The usage of whale fat decreased after Abraham Gesner, a Canadian geologist, initial refined kerosene in the 1840s, enabling brighter light to end up being produced at considerably more reasonable expense (Dolin & Mckenzie, 2007). In the 1850s, the cost of whale fat and oil significantly raised (a lot more than doubling from 1848 to 1856) because of shortages of obtainable whales, accelerating

whale oil's decrease (Dolin & Mckenzie, 2007). By 1860, there have been 33 kerosene plant life in the USA, and US citizens paid much more over gas or kerosene instead of spending over the whale fat. The last loss of life knell for whale fat and oil was probably in 1859, when raw oil was found and the petroleum market came about (Dolin & Mckenzie, 2007).

Gas light was cost-effective a sufficient amount of to power road lights in main towns starting in the beginning 1800s, and was also found in some business oriented structures and in the houses of affluent citizens. The gas layer increased the luminosity of usefulness lighting and of kerosene lanterns. Another important decrease in cost happened around the 1880s with the introducing the electric light by means of arc lamps for huge space and road lighting adopted on by incandescent lamp centered utilities for interior and outdoor light (Kirtley, 2011).

As time passes, electric light became common in countries. Segmented rest patterns disappeared, improved nighttime light made more actions possible during the night time, and more road lights decreased urban criminal offence (Felson & Boba, 2010).

Also due to the invention of different kinds of technology to improve the life quality, one of the most important ones can be the lighting in this regard, so that by combining different technologies in this field, the smart lighting system produced.

Due to the age of the smart lighting that is considered as a newborn sustainability phenomenon, by applying it to buildings according to the need and importance of the place different kinds and designs of the smart light can be applied. According to the

different types of electrical lights and their effect's and costs on human the importance of the decent kind of light can be felled.

1.1 Problem Statement

As the way it was mentioned before the lighting is one of the most important items in the nowadays human life issues, which is playing an important role on the health from the biological and psychological point of view, also it is one of the things in buildings that can be miss used and consume lots of energy specially in the large buildings. Using light in different times of the day can have an effect on the people's health and behavior.

In this field the worldwide known companies have applied the smart lighting system in different kinds of constructions, and the results have shown a decent change in the buildings.

In this regard the information related to the smart lighting system is necessary, especially due to the rapid increase for the use of smart lighting in different buildings due to their beneficial impacts. So that the research problem in this study is to understand the way the smart lighting is functioning according to the needs of the users and designers, and the beneficial impacts on the human life.

1.2 Aims and Objectives

It is obvious that the light plays a very important role in people's life from the psychological and biological perspective, and as an energy-consuming factor, it is an important thing that should be considered in architecture. Therefore, that designers should consider different technologies in this regard to achieve the best goals in this field.

By having it, all in mind the latest technology in this branch is smart lighting, so that in the thesis the following answers are attempt to be answered:

- What the smart lighting is consists of?
- How smart lighting system works?
- How the smart lighting might help by applying it in different kind of buildings?

Within the answer of these questions, the necessity of the lighting in architecture would reveal itself.

1.3 Research Methodology

The theoretical parts of the thesis are from the literature review, which are collected from the books and articles and the internet for the case studies. The descriptive method has been used to explain different parts of the smart light and how the light and electrical sources of light are behaving.

The method which is used for collecting the data is based on qualitative research, and reviewing the data information on different main topic of the study. One is the explanation of different types of light and how it might affect the human health, and also the way the smart light is functioning, finally the examples that has shown the positive impacts on the energy reduction and the human health reactions.

1.4 Limitation of the Study

Due to the expansion of the lighting technology and also the technical criteria's which are included in this system, the color of light and the computer programing, and even the physical and psychological impacts of light on photosensitive people

and exceptional situations are not included, and only a few important parts are mentioned in the study.

Chapter 2

DEFINITIONS, RELATED CONCEPTS OF LIGHT AND LIGHTING

As it was mentioned in the previous chapter, artificial light has always been a critical issue in human life, since the discovery of fire in the Stone Age and until now that the electrical light sources are playing an important role.

However, nowadays the technology from many branches are gathered together to provide the most optimum lighting solution for daily routine.

2.1 Basic Principles of Light

Electromagnetic radiation is usually a kind of strength transfer through periodic variants in the electromagnetic field, and will also end up being interpreted while the motion of particles (photons).

Different types of electromagnetic radiation are categorized in respect with their wavelength or consistency right into an amount of areas and specific zones of what we contact the radiant spectrum, according with their results. In this spectrum, noticeable light ocglassies an exceptionally narrow band (Shaikh et al., 2014).

It is necessary to note that the wavelength (k) as well as the frequency (f) of the propagation of the vibratory motion are linked to the velocity of distribution (c).

Electromagnetic radiation is usually due to variants in the atomic framework of bodies, if the orbital placement of electrons is sometimes differing. On time for their returning to the original placement they will trigger photons to become emitted, the surplus energy therefore being eliminated by means of rays (Shaikh et al., 2014)

In general, there are two primary types of lighting resources can be find, discharge and thermal sources.

Thermal resources emit radiation is the outcome of the thermal agitation of material, and show a characteristically constant spectrum in category wavelengths they cover.

Near room temperature resources release infrared radiation, but as the heat and temperature of the emitter rises, not simply does the quantity of energy playing back enhance but also the utmost wavelength of the peak of wave length towards more and shorter wavelengths. In this true, as ray's temperatures rise it moves in to the broad band of the spectrum, until, at a temperature around 6500 K, the highest in this sector. It really is not a coincidence that temperatures can give the ambiance of the top of sun almost; the field of process of every person's visual capability is opportune to the best values.

in the nature light can be produce and illuminated by many different kinds of physical patterns, such as heat or temperature, nuclear reactions or inflexible smashes.in this regard there are examples that can mention some kinds of these patterns to create the light source, like the fire flames, or the light illuminated from the volcanic magma that are created due to the temperature, or the photo chemical reactions like the glow worms and the shining mushrooms. Also the other kind is the

Nordic light that is created by the primary particles from the sun that are absorbed and trapped in the earth magnetic field in the upper atmosphere, or the sensation of the electric powered discharge which is created in the atmosphere by the lightning, and finally the sun light created by the extreme and scourging plasma persuaded by the hydrogen to Helium. (Health effects of artifficial light European commission, 2012).

2.1.1 The Visible Spectrum

Light is not just transfer the energy but in this regard, it is offering the color due to its different wavelengths in the visible spectrum. So that the important phenomenon in this regard is the geometry settings of light and the environment, like the eye wear of the observer or the shape and reflections in an area. (Shaikh et al., 2014).

The light rays can be controlled and diverged by many types of optical materials and lenses that are mostly created out of crystal quartz or glass in binoculars and telescopes and combinations in this kind. The optical rays are not just limited to the visible spectrum, but also the invisible radiations such as ultra violet and infra-red that the ultra violet is over the visible range of the human eye (the visible spectrum of the light for human eye is 400 to 780 nm) and its frequency is 400 nm and 100 nm, and the infra-red radiation is between the 780 nm and 1mm, but it is important to know that the infra-red can be changed and altered by improved kind of optical lenses and devices. (Shaikh et al., 2014).

The light that is certainly incident to a specific user or observer isn't just dependent on the initial light emission features in the foundation of light, but also on the standard and sometimes frequency dependent light absorption properties of the moderate between your light emission and the observer. Sunshine covers all the

zones of the spectrum and could also become referred to as ' white-colored light'. A particular color corresponds to each wavelength, as in the colors of the rainbow (Shaikh et al., 2014).

Lamination of light could be handled by a number of optical devices or components; most characteristically a beam can be concentrated or diverged by optical lenses which are manufactured from crystal (quartz) or even glass, in binoculars, telescopes and cameras. Optical radiation encompasses but also contains EM radiation of wavelengths well beyond the noticeable range: ultraviolet (UV) radiation can be below 400 nm right down to 100 nm and infrared (IR) radiation can be below and under the mentioned 780 nm up to atone 1 mm. UV and IR radiation may also be altered by optical gadgets and elements such as optical improved lenses (Shaikh et al., 2014).

The UV band can be sub-divided in three wavelength400-315 nm areas (CIE 2006/62471), that can be categorized as the UVA from 400-315 nm, and the UVB from 315-280 nm, and finally the UVC from 280-100 nm.

The IR band can be likewise sub-divided in three wavelength areas (CIE 2006/62471), that can be categorized as the IRA from 0. 78 to at least one 1. 4 pm (pm = one trillionth of a meter), and the IRB from 1 .4 pm to 3.0 pm, and finally the IRC from 3.0 pm to at least one mm (CIE 2006/62471).

the wavelengths between 400 to 780 nm Is generally categorized as the visible spectrum for the human eye

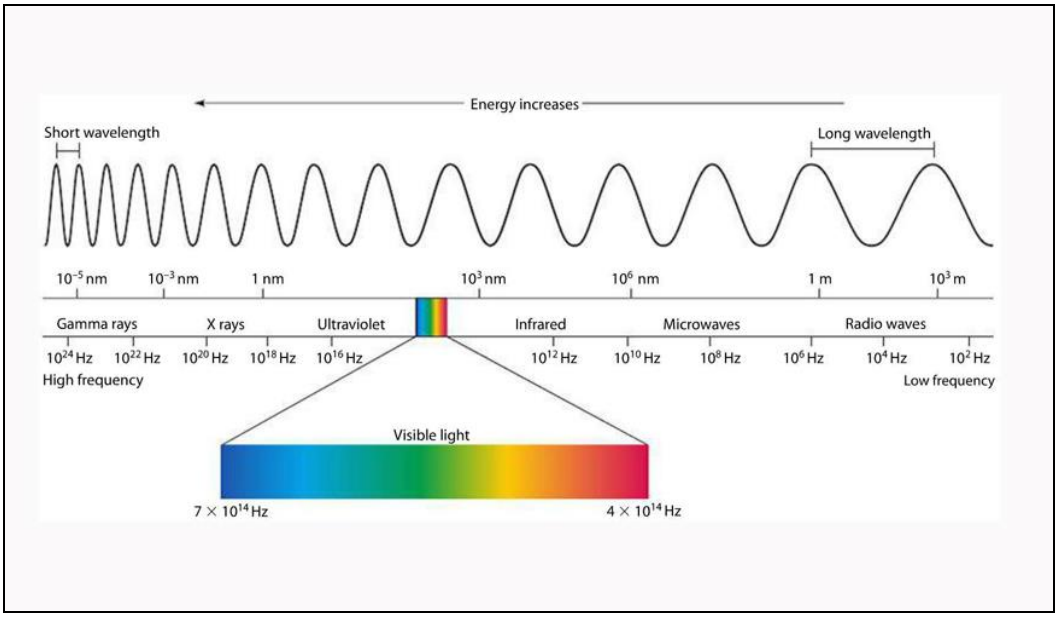

Figure 1: electromagnetic spectrum (Retrieved from https://www.quora.com/What-do-we-call-the-energy-that-is-radiated-continuously-in-the-form-of-light-waves).

2.1.2 Units and Fundamental Equations of Light

There are a few equations that are used to explain the light and their effects, which are explained in the following parts:

- **Luminous flux**

  It measures and evaluate the amount of light in the time unit, also its measurement unit is the lumen (Im).

- **Luminous intensity**

  It gives the quantity of flux due to the needed and mentioned way, also it is shortened and its measurement unit arethe candela (cd = Im str1)

- **Luminance**

  It Specifies the shininess of a surface for a user or observer, also the shorten form of it is L. the unit that specifies it is candela per square meter (cd rrr2).

- **IL luminance**

  It shows the quantity and the measure of the flux the reaches the needed surface, also it is known and abbreviated as E. finally the measurement unit of it is lux (lx):

$ = flux

I = Intensity

E = lEuminance r = reflection coefficient

L = luminance S = illuminated surface (Kim et al., 2004)

A source of light is generally often specified by a color temperature, for example 3400 K for halogen lamps, 4200 K for several fluorescent tubes, and so forth. This nomenclature came about from the actual fact that whenever a light absorbing body (known as a blackbody) can be warmed up, it initial glows further reddish, then cherry reddish, after that orange, until it finally turns into blue white hot. The color of the light glow can be therefore linked to its temperature. As a result, by creating a blackbody color temperatures scale, we are able to compare the color of a source of light to this level and determine to it a color temperature- which usually can be, the temp to which a blackbody should be warmed up to radiate a light comparable in color to the color of the foundation in question. Heat range can be scored in Kelvin that can be a scale which has its zero stage at around 237°C (Kim & koga, 2004).

Totally, a color temperature could be assigned and then a source of light that creates light by heating system, like the incandescent lamp. Various other sources, for example fluorescent lamps, generate light by procedures. These kind of resources are designated a correlated color temperature (CCT), which may be the heat range of a

blackbody which chromaticity many nearly fits that of the source of light (Kim & koga, 2004).

2.2 Lighting

For several years, an unjustified division existed in lighting area and category, which was dividing the lighting in to two disciplines: architectural lighting and lighting practically. Previously the design expression that could be found was that extremely few and little knowledge of visual demands and jobs and also it was revealed the need for the bright and luminary wall washer, lighting elements in architecture, and shadows that could be produced by forms. Finally, the need by consideration to luminary hollow and levels of the ratio, and the style task of the achieved with foot-candles (lux) as the factors and elements which are rulings. That may both these tendencies have been applied for arrives largely to the campaigns of thoughtful architects completely, engineers, and light designers, served partly by the energy education that followed the 1973 essential oil embargo. The last case spurred analysis into pleasurable vision requirements within a perspective of minimal energy apply. That extensive research, and also it owns resulting energy cryptograms and ongoing advancement better efficiency resources, motivated caused by environmental factors are today.

For every job and project, an accountable lighting developers will consider quantitatively and qualitatively, that further a few examples in these regards are going to be mentioned, such as, the integration of the daylight and how it is going to work with the electric light. Also The relation among the electric energy consumption and day lighting and also the mechanical system of the project. The perception and the effect of the lighting on the interior space arrangement and vice

versa. Even The characteristics, incomes of age group, also operation systems of artificial lighting. The requirement of visual demands for special users and jobs (Lechner, 2014).

The placement and the relation between elements and also the psychological impacts of light and shadows which is the pattern of brightness. Finally, as the result of which are equally irreconcilable, and lots of difficult decisions might be in front of the lighting designer (Lechner, 2014).

2.2.1 Illumination Level of Light

As far as the brightness is related and is a proportion of the illumination, so that the previous discussions were about the brightness so that they are related to the illumination. If the amount and level of light goes up around 500 lux, above 1000 lux, there would a noticeable improvement in the performance of the vision. On the other hand, as the illumination starts to rise up drastically the law of decreasing in the improvement in the visual performance would starts to show, and the reason for that is the shrinking of the pupil due to the increasing of the brightness, and if the elimonasion shows a huge increase, only a little improvement would be noticed in the visual performance. Therefore, the reached light to the retinal would be increased a little (Grondzik et al., 2011).

So that the achieve the vest appropriate light in the general elimination the level should be kept under the 300 lux, and the higher level should be used only for special tasks the more light and sources should be localized for the specific task which needs the higher elimination, and therefore it is called the task light (Lee et al., 2012).

The required light and elimination for different tasks is due to some needs and factors, such as the task activity and the brightness of the room, walls (more light is needed for dark surfaces), the speed of activities which is related to that task and also the age of the occupants. As an example, the person visual capability in the age of 20 is 4 times more than a person in the age of 50 and 8 times more than that of a person in age of 60. So that the higher elimination can help a person with the handicapped eyes due to the age (Grondzik et al., 2011).

At the beginning of the design only a rough level of light can be approximately being mentioned for the studies on light modeling and lighting strategies. Otherwise, the specified level of the light and illumination mostly are given to the horizontal surfaces of the task, and the tasks are mostly performed on the desk or table which is around 75 cm high (Benya, 2001).

According to The Standards, the light recommendations is better to be given as the following:

The general lighting of a place is better to be one-third of the task lighting, and the circulation spaces with non-critical tasks is better to have the illumination around one-third of the general space lighting. As an example, an office where the task lighting is around 750 lux, the general lighting illumination can be given as 250 lux, and finally the lighting of the corridors is going to be 80 lux (Benya, 2001).

2.2.2 Quality of Light

In the installation of lighting, the term of the quality of light is going to be used and it is not straightly related to the quantity of light. Like the two rooms that in one of them only one lamp with no other facilities is used and in the other one a ceiling lighting is used, so that there is certainly a huge difference exists between the two

lighting systems. The mentioned difference is among the lighting quality, the whole scene that is described by the term, which is, the lighting sources, flow, consistency, and chromaticity, which is by the lighting (Kelly, 1952).

The glare is the extra light, luminance or the unnecessary luminance and brightness ratio the visual area. In addition, it is important to know that the quality of a lighting system should include that the comfort of the vision in the system, which is related to the absence of the glare. The kind of glare, which is caused due to the light source in the vision field, and it, is called the direct glare. However, the caused glare due to the reflection of the source of light on the surface is called the reflected glare and it is known as veiling reflection. The effecting factors, which are causing the severity of glare, are the eyes adaptation level, the glare source size, which is apprehended, ratio and the level of the luminance, size of the room and surface finishes, also the dimensions of the lighting and light fixtures and their position and windows (Falchi et al., 2011).

2.3 Sources of Light

Nowadays entails a complicated equilibrium of factors, as an example IL luminance, luminance, the view, visual comfort and ease, shading, and glazing types-and associated issues as an example thermal comfort and ease and energy effectiveness. Factually, human actions and tasks had been relegated to hours of sunlight and frequently within proximity of high home windows. Candles and essential oil lamps were costly and a fire hazard, furthermore to offering poor illumination for several tasks. Electrical light began around 1870 with the advancement of commercially usable arc lights and was presented with higher impetus nine years later by Edison's 1st useful incandescent lamp. Advancement of the fluorescent lamp (and additional

electric discharge lights) offers revolutionized the place of work. Buildings it can be mentioned as an example office, malls, and factories are able to run during night hours. The countless new technological advancements in the light industry provide designer a number of energy- effective and environmentally accountable sources and regulates to totally integrate daylight and artificial electrical light in to the design process.

2.3.1 Day Light and the Characteristics

The very much prominent feature of daylight is certainly its unpredictability. The foundation of most daylight may be the sun. Exterior lighting, at a specific place and time, which is dependent upon the solar placement, which may be regulate if the latitude, time, and period is known. Also the climate (for example cloud cover, smog), and ramifications of local topography (natural and constructed buildings and reflections). The positioning of sunlight in the sky is definitely expressed when it comes to its altitude above the horizon and its own azimuth placement. For all latitudes in the northern hemisphere, the sun's altitude is definitely highest in summer season, lowest in winter season, and among in springtime and fall. Azimuth position is assumed as the sun's horizontal placement and position, measured from the southern. Solar position is completely predictable for just about any given period and location.

The sky with cloud, the opposite of the position of the sun, is predictable according to the statistics. At locations apart from those that recorded data can be found, an informed guess is essential (Brown, 1985).

The other factor is the local topography and the building situation, which also decrease the light due to the shadow they might produce or increase it by means of the reflections that might occur that can happen only case by case and the case foundations basis (DeKay & Brown, 2013).

To do the calculation without computer, the only thing to do is just start and consider four conditions of the sky, which are the completely cloudy and overcast sky. The other one that can be mentioned is the according to the field of view, the clear sky without cloud and sun, and also the sky with sun and no cloud. And finally the partly cloudy sky (DeKay & Brown, 2013).

2.3.2 Artificial Light and Characteristics

the luminescence for human was not something just some kinds of materials to be burnt and create the light, for many years and centuries, also it was not hidden for human that the light has the potential to be produced without heat. Therefore, bioluminescence (in this category the glowworms or firefly's and the glowing mushrooms can be mentioned), and the materials which have phosphor and lightning in nature were discovered for early human as a source of light. The burning materials or the fire heath materials which in this regard the candles and gas lamps and many other different types, which use a chemical material which shows reaction to heath and generate light for burning, are still in use all around the world by people. According to this kind of light it should be mentioned that the light and its quality is very low and also the color is not very mush suitable, generally it can be mentioned as quite unhealthy kind of light due to the low and limited heath of the burning material.

Although the electricity is used nomads all around the world by human for illuminating the environment, there are still some people even in the main parts of the glob that they do not have access to electricity for generating light, and these people that are around 1.6 billion are still using the old fashion type of light which is the burning materials. In 2005, something around 19% of the electrical energy which had been used for producing 133 (Plmh) peta Lumen hours, and also the electrical artificial energy which is represented as 3418 Tw of electrical power, (Brown, 2009). Normally the electrical power which is around 43% used for blighting up tertiary use buildings, and also the residential and housing energy consumption related to lighting is around 31% and also the commercial and generally the nonresidential buildings that are using the 18% of the energy, lastly 8%is used for the outdoor facilities like signaling. In today's world the light source systems can be categorized in the system of incandescent ones and the other one is the luminescence type, that this one is including the fluorescent and SSL (solid state light) the the well-known LED is in this type. (Schulmeister et al. 2011).

It is wisely being noted that there surely is this kind of a variety of items between each light technology which is available, that it's oftentimes, very difficult to provide emission spectra which are "typical" for accessible and suitable types of the lamps.

Regarding some lamp systems, additional bulb or glass envelope may also be present. Most types of the glass absorb a quite huge and considerable segment of the UV rays, also in the ultra violet radiation the thickness of the glass or the protection can play an important role in this regard, which means the ultra violet types C, B also the short wavelengths of the UV cannot penetrate the glass very easily. According to

the soda lime and SI02 glasses that might be use in the lighting industry, they do not have the potential to block the ultra violet to pass. Surprisingly the normal heat resistance type of glasses, such as Pyrex can stay against the UV types B and C, and to improve this potential using and mixing those with some other kinds of UV blocking materials this stance can be improved. For some kinds of lamps, the second protecting shield, made out of soda lime glass is increasing the protection like High efficacy incandescent as well as ceramic metallic halide lamps. According to the polycarbonate materials such as Plexiglas the UV, protection can be increased drastically. They have the potential of blocking the ultra violet types B, C and 90% of the UV emissions of the lamp. Furthermore, you will be able to use a special kind of filter (GAM 1510 UV shield) that is present by means of a gel or Rosco layer (03114); this could be used to cover the lamp bulb and removes a lot more than 95% of UVA radiation. Lastly, whenever a lamp is positioned in a luminaire or fixture, UV blocking elements (such as for example soda-lime glass or polycarbonate layers), the system should use and reduce in a noticeable amount UV radiation rays. However, as this kind of situation is not compulsory rather than rule, it is encouraged to have the danger of the UV radiation in mind (Schulmeister et al., 2011).

2.3.2.1 Electric Light Sources

It should be mentioned that the two necessary and important features of the light sources could be, the level of the Luminous is effective as well as the way the colors of the ambient light would be seen and rendered CIE (1995). One of the properties of the light source is the interpretation of the colors that show and reveal the shadows of objects would be seen natural under the source of light. If the quality of it is not good enough, that source would never be used for general lighting of the place, CIE (1995). the most important reason that the world has accepted the use of the solid state lights should be mentioned its very efficient energy consumption.

The behavior of the light and the requirements of the work place are the most important aspects to compare and select the light source.

The way of transformation and changing of the electrical energy to visible light and the transformation of the optical light to the luminous flux, are the performance of the luminous of a supply depends upon these two elements. As the shadow range of the light source creates the effectiveness of the luminous as well as the interpretation of the colors, is luminous efficacy.

2.3.2.1.1 Incandescent Lamps

The process of illumination in an incandescent lamp is through the heating of a tungsten string by the electric power until the string is reddish white-hot. As the heat rise up in the tungsten string the light gets whiter, (color temperature gets higher). Unluckily, as the filament gets hotter, also it burns out much faster. Therefore, the companies and producers try to make and design their own optimum incandescent lamp to last longer and perform better. The performance life of a common type of an incandescent lamp is around about 1000 hours (Kumar & Halpeth, 2004).

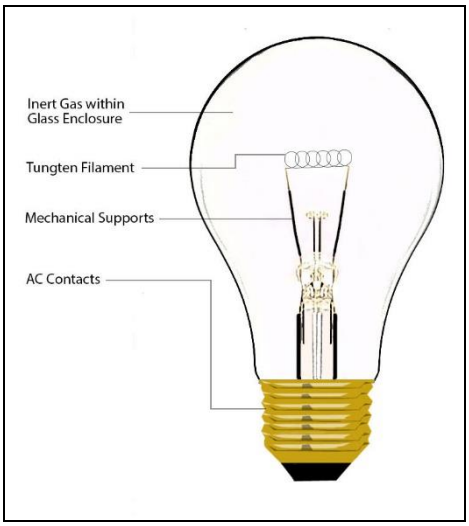

Figure 2: Incandescent Lamps structure (retrieved from https://www.microchip.com/design-centers/intelligent-lighting-contro)

2.3.2.1.2 Discharge Lamps

Most of these lamps derive from a phenomenon referred to as discharge, where an ionized gas rather than glowing incredibly hot solid tungsten filament emits the light. All discharge lights require a supplementary device referred to as a ballast, which initial ignites the lamp with a higher voltage and limits the electric energy to the correct operating level. Traditional ballasts which were manufactured from copper coils are getting replaced by digital ballasts, which are better and much less noisy. The digital ballasts also get rid of the issue inherent with magnetic ballasts making 120 flashes per second, which disturbs some delicate people.

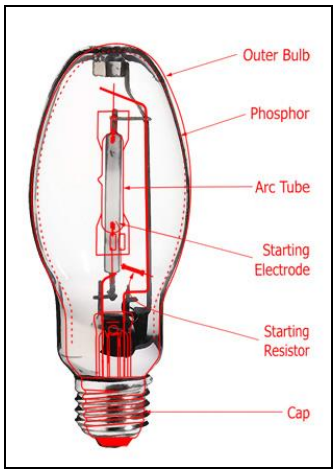

Figure 3: Discharge Lamp Structure (Retrieved from http://www.primelite-mfg.com/light-bulbs-high-intensity-discharge-lamps/)

The extended life and high effectiveness of the discharge lamps are more than of to offset the excess price of the ballast and the bigger cost of every lamp in comparison with normal incandescent lamps.

Even though discharge lamps are far better for durability than incandescent lights, some possess the essential liability of using the poisonous component mercury. Lamp producers are improving discharge lamps to use much less mercury, however when the lights are disposed, the mercury gets into the surroundings (Kumar & Halpeth, 2004).

2.3.2.1.3 Fluorescent Lamps

Even though the fluorescent lamp was initially released in the 1930s, it really is still among the best light sources. It really is available in a multitude of sizes, shades, wattages, and styles. Due to the cautious about energy, small fluorescent lights (CFL) have already been developed that may straightly replace the significantly less effective incandescent lamp. The lately created amalgam CFL can be more broadly appropriate since it is a lot less delicate to the ambient temperatures. Due to global

warming, it really is vital to minimize the usage of incandescent lights, and CFLs make that simple and actually cost-effective (Kane & Sell, 2001).

According to the fluorescent lamp, rays is usually released from a low-pressure mercury vapor that is ionized. Since a lot of the radiation is usually in the ultraviolet section of the assortment, the within surface area of the glass pipe is covered with phosphors to make the invisible radiation converted in to the visible light to human eye. With different types of phosphors, fluorescent lights are capable to be made to emit numerous kinds of white-colored light. For instance, warm white lights emit more energy in debt end of the assortment, while decent and acceptable white lights emit more energy in the range of the blue. Specifically formulated fluorescent lights are available that provide exceptional color rendition.

As the light can be emitted from the top of glass bulb instead of a point like supply, fluorescent lamps are not best for beam control. Finally, Among the best fluorescent lamps is now able to stay working around 46000 hours.

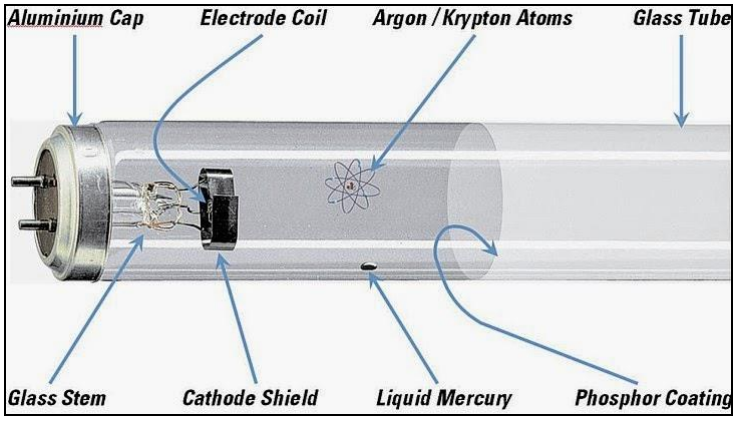

Figure 4: Fluorescent Lamps structure (retrieved from https://hebasoffar.blogspot.com/2014/06/uses-of-fluorescent-lamps-and-their.html)

2.3.2.1.4 Neon Lamps

Neon lights are close family members of fluorescent lights. These lights use this kind of gases as neon, gives off reddish light, and argon, gives off blue light. By using different combinations of gases, colored glass, and phosphors, a big selection of rich, colored light sources can be done (Kumar & Halpeth, 2004).

The benefit of these lights is they can be custom- designed to nearly every desired form. Neon, which uses regarding 0. 5 in. (13 mm) diameter cup tubes, could be bent into highly complex shapes. Neon lights have lengthy lives around 25000 hours. Neon isn't ideal for area lighting as the light output is about 7600 hours. Rather, it really is befitting applications that want special colors and designs. These lights are the most suitable when the form of the lamp is usually carefully integrated with the proper execution of the architecture or when the form of the lamp is usually itself the look element (Lechner, 2014).

2.3.2.1.5 High Intensity Discharge Lamps

There are 2-noticeable feature, which is common in all the High intensity discharge lamps. A few minutes is required for them to reach their highest potential outcome, on the other hand after a voltage interruption they would not restrike immediately. A disadvantage about these types of lamp is that they need about five minutes to cool down to be able to restrike the arc again. Also there are special types of lamps in this kind that has the capability to restrike immediately to help people from being left in the dark.it should be consider that, if this kind of lamp is not used so that another source of light such as a fluorescent lamp should be used to support this interruption (Lechner, 2014).

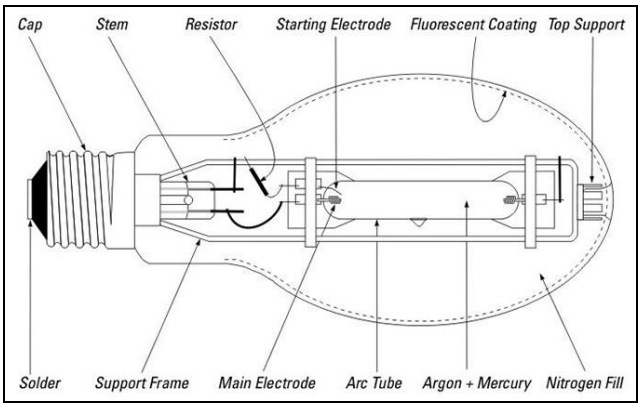

Figure 5: High Intensity Discharge Lamps Structure (retrieved from https://www.ledwatcher.com/high-intensity-discharge-lamps-explained/)

2.3.2.1.6 Mercury Lamps

In addition to have less effectiveness than various other discharge lights, mercury lamps have got poor color rendition. They create a cool light, abundant with blue and green and deficient in debt and orange elements of the spectrum. Because of the blue-green light, mercury lights work in landscape light, but or else they are believed obsolete (Lechner, 2014).

2.3.2.1.7 Metal Halide Lamps

The white-colored light that metal halide lamps release is slightly, a cool color however; there would be energy in every area of the spectrum to provide very great color delivery. Metal halide lamps work the best for shops, office spaces, schools, commercial and industrial areas, and exterior spaces where color performance is definitely important. These lights are among the decent resources choice of light nowadays because many considerable features are merged in just one lamp, such as, high efficacy (50-110 lumens/watt), acceptable life (20000 hours), very good and acceptable color rendering, and little size for optical control. Among the essential improvements in metallic high intensity discharge (HID) lights have become efficient light resources that in proportions and forms are similar to incandescent and also fluorescent lamps, but like all discharge lamps, they need a ballast to function.

In every of the high strength discharge lights, the light is definitely emitted from a little arc tube located in the protective outer light bulb.

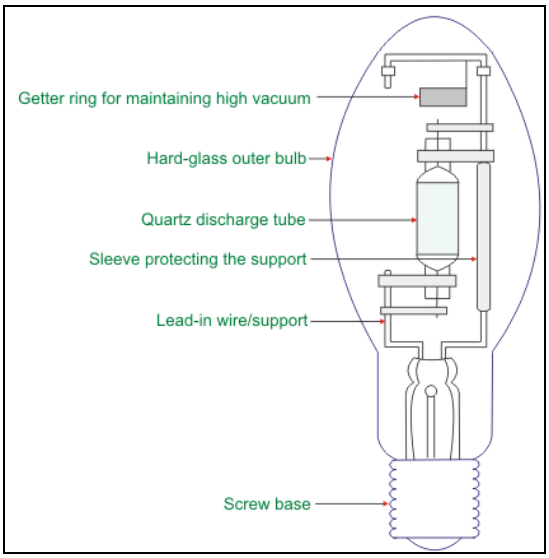

Figure 6: Metal Halide Lamps structure (retrieved from https://www.electrical4u.com/metal-halide-lamps/)

2.3.2.1.8 Light Emitting Diode (LED)

A light emitting diode (LED) is a semiconductor light source. LEDs have been used as indicator lamps in many applications and they are becoming more popular as lighting devices in recent years especially with energy saving applications. LED technology was invented in 1962 by Nick Holonyak and found its way into consumer devices since then. LEDs in early versions emit low intensity red light, but modem versions are becoming more capable and are able to emit various wavelength including wide range of visible light, ultraviolet and infrared light (Pode, 2009).

Producing white light is more difficult and expensive in comparison to other wavelength of visible light. One of the most used technique to produce white light is by illuminating phosphors with blue LED to make white light. The other widely implemented technique to produce white light especially in TVs and computer

monitors is called “RGB method” in which the light from a set of red, green, and blue LEDs is combined to achieve white color.

One of interesting property of LEDs is that the light emitted from single point of light source in specific direction. This peculiar property makes them excellent source of light where spot or narrow beams are needed. They are, therefore, optimum replacements for all incandescent reflector lamps and CFLs used for downlights. This degree of directional control can make it possible to minimize the waste from spilled light, glare, and light trespass, which is important in outdoor lighting (Edirisinghe, 2012).

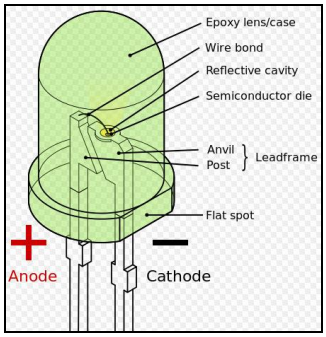

Figure 7: LED Structure (retrieved from https://www.dreamstime.com/light-emitting-diode-led-structure)

One other interesting fact about LEDs is the low waste of energy, unlike all of the other light sources, LEDs produce very little heat in the form of infrared radiation, which make them highly energy efficient in comparison to the other light sources

LEDs technology is relatively new technology and could be developed into more elaborate lighting source and increase its potential where as other light sources are literary reached to its theoretical limits where no reasonable development are expected to come in near future (Edirisinghe, 2012).

Also it can be mentioned that the LEDs definitely have benefits that makes them a decent source of light in the smart lighting, Among the potential great things about LEDs compare to other sources even from the ecological point of view, like the Discharge lamps, is usually that they make use of mercury, the LEDs have no Mercury.

2.3.3 Lamp Emissions

To find out the hazardous information about different lamp types exposures, the collected data and information about the lamp type emissions andoccupapational exposure is necessary to reduce the negative impacts of the lighting system emissions. Available measurements performed by some researchers have provided substantial information regarding light emission which could be used in this opinion. In addition, a recent study from Schulmeister and coworkers, (2011) provided worthy detailed spectral information.

Just in the study from Schulmeister and coworkers, (2011), in very complete information and data release spectra (with nm resolution) is mentioned. Due to the full emission spectrum according to all lamp types, some scattered information is available.

Different kinds of threat and danger can be mentioned as follow: The dangers of the UV for the skin as well as the eye, which that the UVA is dangerous for the eye, as the way that blue light can threaten the retina. Also the thermal hazard, which is related to the IR and has its own negative impacts on the eye.

In regards to well established standards, measurements performed in two different ways; the first way is to find at what distance the light intensity of 500 lx can be

reached and the second way is the measuring of the light intensity at the distance of 20 cm. Based on these experiments, lamps are then categorized into the "Risk Group" (RG) to which they belong. RG0 (exempt from risk) and RG1 (minor risk) lamps do not cause any damage during normal conditions. RG2 (medium risk) lamps also is not hazardous because of our natural repulsion to very high intensity light sources. RG3 is the high-risk category of the lamps that can cause a serious damage in a short period of time that in this regard is indicated to the 8 hours of exposure for people with normal sensitivity Six lamp types from various lamp manufacturer where chosen by European Lamp Companies Federation (ELC) to be classified as "representative lamp types". These lamp types then classified base on EN 62471 standards which produced the following lamp types:

- Tubular fluorescent (4,000 K and 6,000 K);
- CFL (2,700 K 11W with and without envelope);
- LED (3,000 K, retro-fit, and 6,000 K);
- Halogen (two high voltages, one without UV filter, and three low voltage);
- High pressure discharge (two metal halide and one sodium); and
- Incandescent (60 W clear).

Most of the lamps are categorized as RG0 (exempt from risk) due to the classification of the light which is done from before due to their emissions, or they are categorized as RG1 (low risk) from UV and IR radiations, but there is one exception that the Halogen lamps are designed and should be used with extra protection layer that can be a glass shield, on the other hand it was classified as rG2 and also RG3 with only 20 centimeter distance from the source and also with no shield and protection. According to ELC. The metal halide lamps can be categorized

as RG1 and RG2 under 20-centimeter distance, but actually, they are not meant to be used under this distance and short distances.

The 6,000 K LED (“high power" LED), just like other lamps are considered as RG0 or RG1 according to ELC for the blue light emission, it also means that as a small source of light it is RG0 under the 20 centimeter.

Besides, it is expressed that the lights were chosen in a way that are typical, mid-range samples from the quality control process.

The outcomes exhibited in the ELC report propose to SCENIHR states that there is next to zero risk to people with normal sensitivity from the UV IR or blue light optical radiation emission from lights which are considered as “representative” of the kind of lamp s to replace incandescent lamps. SCENIHR however considers "non-representative" lamps might radiate emissions Lamps that are design and are mentioned to be used with the second envelope should not be used under the normal situation without the shield, due to the ultra violet emissions of the light source Due to the photosensitive patients who might suffer because of the improper kind of lighting in different areas, a special attention is needed to decrease these problems. A study has shown that the patients who are suffering from photosensitive dissorders might show erythematous reaction to the CFL light emissions with only a single layer (Eadie et al. 2009).

This study is done around the 5-centimeter distance from the source of light, which is quite acceptable due to its limited heat to be used for the task light, but the hazards have made this light in the RG2 category. Since lights that are designed to be used

near the user should be categorized for a distance of twenty centimeters, it should be mentioned that a CFL with a single layer is categorized as RG1 may make for a person who is photo sensitive can be endangered if the light source be used under the twenty centimeter. Also in this study all, the lamps had been chosen from the RG0 or RG1. The solution and answer to the problems of the photosensitive people is very difficult, due to the different wavelengths that each lamp type scatter and also the behaviors of the photosensitive patient's reaction is not known, but generally the RG1 lamp types are not recommended to be used by this kind of people.

According to ELC, all the CFLs that are examined and are mentioned in the reports are categorized as RG0 and RG1, which is showing that they do not have a serious kind of danger for normal people, but unfortunately it is not clear that if they might be dangerous for photo sensitive people or not. Due to different reactions to each wavelength of light emissions that photo sensitive people show, it is recommended that these people should not use the RG1 lamps.

Further study about light emission from 167 CFLs (103 single layer and 65 double layer) showed double layer lamps generally emitted much less than single layer lamps (Moseley, personal communication). Taking the highest emitting lamp of each model tested, the mean UVB irradiance was 4 mW/m2 (double layer) and 101 mW/m2 (single layer).

Although UV radiation is recorded about the Halogen lamp emissions, it is not considerable as much as other lamp type emissions (Schulmeister et al., 2011). It is noted that there is no recorded data or information according to the hazards behaviors

of the Halogen lamp emissions on the photosensitive patients, but using the halogen lamps that has no filter is not a good choice for being used for these people.

2.3.4 Operating Lighting Technology and System

2.3.4.1 Conventional Lighting System

This is mostly consisting of different types of lamp technologies, such as incandescent lamps or CFL and corresponding luminaires and lighting electronics and starters.

Furthermore, it should be considered that mostly in this system, all the controlling is done manually and computer and measuring sensors has no place. So that it can be mentioned that this is the most common kind of system which is being used at least since nowadays (Grondzik & Kwok, 2014).

2.3.4.2 Smart Lighting

There are two primary energy saving actions could be followed: efficiency and effectiveness: efficiency, by new more advanced performing tools (lamps, control gear, etc.) and by implementation of enhanced lighting design process (localized task lighting systems); effectiveness by improvement in lighting control systems to decrease energy waste and by implementing a technical building management system (maintenance and metering). By controlling the lighting in a way that the lighting intensity always equivalent to the actual needs of user to save on the energy costs and to improve comfort and efficiency.

In this regard smart lighting systems, that can be considered as the next level in the lighting technology modernizes the old fashion lighting control with the help of

applying reaction according to the inputs of the users and also integrated sensors to use the created light result.

Due to the importance of smart light which is the main part of the thesis, so that in the next chapter it is going to be explained more in detail.

2.4 Effect of Light on Human Health

2.4.1 Psychological Aspects of Light

The environment and surroundings are seen and understood due to the light, which is received to the eyes, but it is the brain that is analyzing all the received information from the eye and it is judging and evaluating the surrounding due to the light, which is available. The brightness of the place and its quality can be evaluated in many ways that the light related to the activity in the place is acceptable and decent or not. The level and variation of lights as well as the hue of the light has the potential to increase or decrease the feelings, the mind set and it has the ability to influence the human activity. In addition, it should not be underestimated that the people's perspective can have an impact on the effectiveness of the light. On the other hand, although the light in a place might increase the visual representation, if it is not satisfying the desires and the needs of the user, it can be considered as unsatisfactory light, and it might drastically influence the productivity of the person in an area. (Boyce, 2003).

Other understood mental effects of colors are the coolness of blues and greens and the glow of reds and yellows. So cool colors likely could be used in a fur salon and warm color in a summer wear. Red and yellow are "advancing" hues since anything lit with them would be perceived bolder to the eyes of observer, giving the quality of

bulkiness. The opposite effect is perceived with blue and green, accounting for their being known as “receding” colors.

A sensible implementation of these color phenomena in energy-saving application would be to use warm colors to balance heat generation in the winter and cool colors for the opposite effect in summer. In order to accomplish this energy-saving tactic without repainting interior twice a year, designers should rely on their ingenuity designing the interior. In a space where needed to be calm and restful, green color should generally dominate either in illuminant color, object color, or both, except in eating areas, which should be lighted with reds and yellows because cool colors are rather unappetizing. Yellows and browns bring out the sense of motion sickness, whereas blues and greens are the opposite. Warm and saturated colors induce the sense of activity; conversely, cool, unsaturated colors are very useful for relaxation. Cool colors also make the passage of the time shorter and could be used in areas where the dull and repetitive works happen. Although the colors and the behaviors of light in this regard might be necessary for the lighting design and the mental performance, due to the expansion of the light color which is playing an important role in the interior and exterior designing, and also the limitation in this regard, in this thesis the colors and their effects are not going to be evaluated).

The mood and desire of the users whether in a public or private space can be positively impacted by the bright light due to the vision improvement. In addition, it should be considered that the color temperature, which is an important feature of the light, should be designed and considered according to the place and space.by considered the given information the person who is using the place would show an

immediate and moderate speed kind of response in the circadian rhythm due to the lighting.

Due to the natural behavior to the spectrum and intensity of the sun light, the same thing is tried to be interpreted by the artificial light, which is recently studied on the psychological and sleeping cycles in systematic manner.

2.4.2 Non-visual Aspects of Light

Light has also effects that are fully or partly separated from the visual system. These are called the non-visual, non-image forming (NIF) or biological effects of light and are related to the human circadian photoreception.

The revelation of the novel third photoreceptor, naturally photoreceptive retinal ganglion cell (IPRGC), in 2002 has brought huge interest both in the circadian biology and lighting research scholars (Berson, 2003). The photo receptor which is in charge for making the people entrained for the dark or light cycles behaviors from the ecological point of view seems to be IPRGC, alongside the other ecological effects.it is the answer to the biological effects which is triggered and control by light, so that light in this manner can be considered as an external feature which is making and entraining the internal biological clock of the body to function in the proper way. The biological clock of the body is responsible for the physiological and behaviors of the body cycle rhythm, that in this regard the slip cycle and the main body temperature as well as the hormonal secretions of the body can be mentioned.in this system the information is passed on to regulate the hormonal function and secretions, such as nocturnal pineal hormone, Melatonin and as well the serotonin.

Besides the light can shift the internal cause and origin clock phase, also the pupillary reflex is documented IPRGCs should also be involved, in the way that human response, and the level of the mood and alertness. In this regard, the short wave length of the light has shown the most impact on the biological clock.

Although the light has shown that its very positive impacts, one the other hand its existence during sleep hours can has a dramatic impact on the breast cancer, sleeping behavior disorders, cardio vascular problems and also gastrointestinal. The most important aspect in this regard is the light itself and there is no correlation to the lighting technology. (Talebian, 2012).

The blue light has shown the most effective impact on the biological clock of the human, compare to the other light wave lengths.in this study the blue light or the monochromatic light enriched with blue suppress the melatonin secretion or its cycle. (Talebian, 2012).

2.5 Chapter Summary

One of the principles of physique is light that is an electromagnetive radiation from different wavelengths. In this regard, the visible spectrum for human eye starts from the infrared to ultra violet radiation, that each one has its own special behaviors and are divided into sub categories, which had been explained. After the invention of the electrical bulbs, different kinds of lamp with different natures has been discovered, like the incandescent lamps emits the warm color temperature that on the other hand the florescent lamps light has cooler color temperature. Finally by invention of the light emitting diodes the light industry enters a new era that by using less energy a decent amount of light could be absorbed, on the other hand it has the capability of

adjusting its color from warm to cool color tempreture.in this manner it is discovered that each kind of light has a different kind of impact on the human health from the psychological to the physical point of view, so that in the next chapter the new technology which is the smart light would be discussed more in detail. The capability of changing the light behaviors according to the situations and needs would be mentioned.

Chapter 3

SMART LIGHTING

Lighting or illumination can be the planned usage of light to attain a useful or artistic effect. Light includes the usage of both artificial light resources lamps and light fixtures, along with daylight lighting. Daylighting (using home windows, skylights, or light shelves) may also be used as the primary way to obtain light in daytime in structures. This may save energy instead of using artificial light, which presents a significant element of energy consumption in structures. The type of lighting with appropriate lux, no glare, and decent color temperature (it could be changed slightly in various rimes of your day and year) can boost activity efficiency, enhance the appearance of a location, or have positive emotional effects on occupants.

Indoor lighting is normally achieved using light fittings, and is an integral part of home design. Lighting may also be an intrinsic element of landscape projects.

Recently, the amount of types of artificial light resources with different physical character, brightness, color temperature and also the form factor considerably increased.

3.1 The Positive Impacts of the Smart Light

The capabilities about smart light systems are numerous, the majority of immediate becoming improved energy savings (Park et al., 2014; Wang et al., 2012). Actually, systems with built-in energy-saving light control commonly show energy cost

savings of 17-60% over traditional lighting control based on occupant utilization patterns (Von Neida et al., 2001), These energy-saving smart light systems are usually installed in office structures because they have the highest prospect of power consumption reduction and so are relatively simple to retrofit (Santamouris & Dascalaki, 2002), Over and above that, smart lighting may be used to enhance quality of light, control circadian rhythm (Oh et al., 2014), enhance efficiency (Karlicek, 2012), speed up plant development (Massa et al., 2008) and apply human-centric light, among other benefits. Therefore, it could be argued that the advancement of sensible lighting systems could have a positive effect on industrial applications and analysis on horticulture, architecture, building administration, control over the quality of life and individual physiology.

Furthermore, recent developments in sensing technology reveal the new horizon to a bunch of feedback details previously unavailable. Accurate occupancy details like user area and activity, the data and information from the light spectral from micro spectrometers, and more potent light information for example chromaticity and luminance division could be exploited to build up smarter algorithms that enhance energy performance, user satisfaction, ease and comfort, light quality, and efficiency of smart light systems. Furthermore, compatible technology for example Visible Light Transmission (VLC) (Karunatilaka et al., 2015) may also be created for integration with innovative smart lighting tools.

Light control systems which will be the area of the smart light program reduce energy use and cost by assisting to provide light only once and where it really is needed. Light control systems typically integrate the use of period schedules, occupancy control, and photocell control (such as daylight harvesting). Several

systems as well assist call for response and can automatically dim or switch off lights to benefit from utility incentives. Light control systems are occasionally incorporated into bigger building automation systems.

Many more recent control systems are employing wireless mesh open specifications (for example ZigBee), (Bellido-Outeirino et al., 2012) which gives benefits including easier set up (you don't need to run control cables) and interoperability with additional standards- centered building control systems (Tariq et al., 2012).

According to daylighting technology, daylight harvesting systems have already been developed to help expand reduce energy usage. (Cheng & Huang, 2010; Li et al., 2010).

3.2 Diagnosis of Individual Response Type of Lighting

One of the notable benefits of smart light devices can be sought to utilize optimum lightning condition for a particular user with certain hardware equipment. For instance, to mitigate user exhaustion from absence of day light, a simple yet effective hardware equipment can adjust lighting environment for user and thus, improving mental and physical health of users. (Berlov et al., 2015), adjusting the light for a proper light condition must also take individual response into account since each individual may have different response to a particular light regime.

The selection of certain diagnostic method that helps evaluation of light setting is necessary in every individual case. For instance, any chosen diagnostic method may vary for different age and sex, in order to evaluate any parameters, unique particular methods are demanded. Advancement and selection of a practical diagnosis requires the right collections of individual lighting programs.

There are some compelling methods of diagnosis that can be used in short period of time. Functional states of brain can be rapidly evaluated by these compelling methods which bring a great deal of results. Some of the very well-known lab testing methods for assessment of “sensoria and motoric” are as follows: bimanual tapping test, eye-dominance by DiHaploscopis Technique (DHT), bimanual sensomotoric reaction (Berlov et al., 2015). One notable method which shows a promising result in lab is to evaluate “the critical flicker fusion frequency”. With this particular method of testing, human nervous system can be evaluated for any reaction to light exposure.

This method of testing and measuring has been practiced in various labs for a quite long time. The critical flicker fusion test has become a standard procedure for assessment of physiological liability according to the physiological college of Vvedenskii Ukhtomskii. It can be regarded as the crucial parameter of the nervous system, which usually determines its response to exterior stimuli (VVedenskii, 1952; Berlov et al., 2015), Critical flicker fusion frequency is being used to measure the functional states of mind such as exhaustion both in laboratory circumstances (Simonson, 1959) and in the production (Vinogradov, 1966), for medical targets (Gregori et al., 2011; Berlov et al., 2015).

3.3 Smart Lighting System

Smart Light consists a heterogeneous and a comprehensive region among illumination management, with the chance of including an expanded group of sensor and control technology, as well as information and communication technology, with the purpose of obtaining an increased efficiency and much less negative affect produced from the usage of energy for illumination, in conjunction with improved smart functionalities and also interfaces of light in the environment.

According to the given information, the study concentrate for recent programs upon this area is principally presented on digital allowed and controlled light interfaces and systems, permitting lighting functions to be more powerful, controllable and interactive, and adaptive based on external and inner variables, contributing on more smart lighting solutions.

Smart Light includes the utilization of smart functionalities and interfaces at four complementary stages:

- The embedded level which is the first level is the light source itself.
- The system level which is the second level, is in luminaries and lighting systems.
- The grid level which is the third level, includes management and monitoring of the sources of power, energy generation plants and division programs and devices.
- Communication and Sensing Level that is considered as the fourth level, is in complete lighting possibilities by means of monitoring, control and management programs.

Smart Light has sped up study regarding the effect of light and light on human (in wellness and also natural behavior), animals and vegetation (Chew et al., 2017). It has recently led to an improved understanding of the need for light for human being and animal comfort and ease convenience and well becoming in homes, schools besides for higher efficiencies in labor offices and industrial environments.

according to this method, M2M Communications and Internet of Items Technologies provides features for planning, increasingly specific concerning the set up and

monitoring of lighting systems predicated on several variables which may have an effect on. All of the gathered measurements, stored, prepared and properly analyzed can provide response to the question of what can be the decent area for installing a kind of specific light, in addition to what sort of power generation devices is appropriate to install with respect to the results, thereby achieving optimum performance among the alternatives.

when it comes to the smart controls having a street light network necessarily should be managed. The new and recent idea of the smart cities in the physical world has brought up the new point of view on the cities and the new generation of applications by the data guides is feeding the systems that some kind of decisions as notifying to a particular services parameter. These all are the main factors to improve the elements such as energy efficiency and effectiveness, to use the sources much wiser. (Chew et al., 2017).

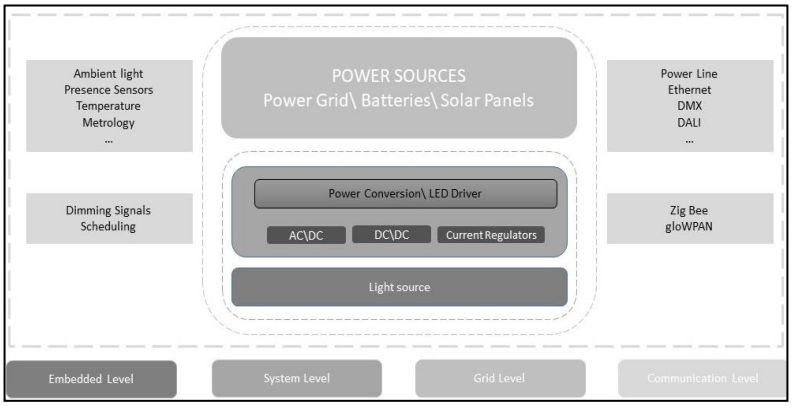

Figure 8: Smart Lighting Integration Levels

3.3.1 First Level: Embedded Level

According to the previous chapter and the information which has been mentioned before, choosing the right source of light is one of the most important items in the

smart lighting systems. In this importance the maintenance and the usage of the place and also the first budget is playing an important role to choose the light source.

Although all the mentioned information is dictating what kind of light source is important such as different types of florescent or Sodium halide lamps, one of the principal Smart Lighting enabler has been the introduction and emergence of semiconductor based digital light sources such as LED (Light Emitting Diode) and next generation LED technologies such as Organic Light Emitting Diodes also known as OLEDs or Solid State Light (SLL) sources.

The lighting sector is working on the most known changeover because the introduction of electric bulbs in the 19th century. Current business versions are getting checked out and upcoming market potential has been evaluated against those versions. This is because of the speedy emergence of LED light that's transforming the technical and ambitious situation (Khanna, 2014)

3.3.2 Second Level: System Level

It delivers light for users and occupants of the building when required within an efficient way, in keeping with any relevant building and energy requirements. To decrease the necessity and price of lighting areas a control program can make use of day light as much as possible. It can be often known as “daylight harvesting” or “daylighting.

due to the lighting system control the importance of the smart controllers reveal themselves, that they are distributed in the the relay panels. In respect to the controllers and also the system and device controllers it should be mentioned that they are also distributed within the Ethernet system and have the sending and

receiving the schedules as well as overriding them. To get the best out of the controllers about the energy conservation and receiving the best functionality, the controllers could be interfaced within a paner instead of having a workstation for monitoring and controlling system to regulate and control the lighting, which in this regard the method of dimming can be mentioned.

Modularity in system controllers allows for further adoptions. Various ports and interfaces such as Ethernet port allows the system controllers to have simultaneous connections throughout the network system. Each panels can establish a stable connection to the controller via an Ethernet connection or different kind of protocols (such as LonTalk, Modbus or BACnet protocol) which are routed through main IP network.

Implementations of artificial intelligence and control ability protocols to each individual component can be considered throughout the lightning control network system for every lighting ballast. This process made the control to be focused and centralized to the server and also permits network interfaces to particular products (Sinopoli, 2009).

3.3.2.1 Relay Panels

Relay panels are usually installed following to the electric circuit breaker panels. These circuit breaker panel delivers in to the relay panel with the relays located in the relay panel performing just as a switching gadget for the circuit. Relay panel categories could be provided with several voltages inside the exact panel. Every single relay could be separately programmed throughout the system controller and the relay panel (Sinopoli, 2009).

Relay panels offer collection voltage control of the light energy demands; they enable an individual circuit to supply inside a number of relays and for many multiple circuit breaker panels, which will supply right into a one-relay panel. Although relay panels could be programmed or managed by {a system controller, they are able to also function without the procedure controller. The relay panels routinely have position indicators for the relay outputs, dry get in touch with inputs for system override reasons, and also the given information and data for monitoring products, like photo cells and as well, occupancy sensors (Sinopoli, 2009).

the relay panels in multistory buildings could be installed on each floor, and each one can be programmed accordingly.in every floor the master panel has the responsibility of controlling all the lighting within the floor, and in every floor, each room or space can have a local panel that is working due to the needs, also is programmed according to that space. To clarify the situation, it can be mentioned as a n example that the lights within a floor can be turned off at 6 pm and turned on at 7 am, exactly the time that light is needed and the rest of the times the floor would be dark, in this situation turning or swiping off the electricity of the lights are in control of the master plan of the floor, and it is done according to the programs that is provided to the relay panel. (Sinopoli, 2009)

3.3.2.2 Dimmers

According to The segment of the dimmers, it should be mentioned that they have the responsibility of controlling and providing the electricity to the low voltage switches and series, which needs the low voltage. Dimmers are mostly used to improve the light quality of the series of lights and the lighting of the space, so that in this regard the individual dimmers each one are equipped with an analog input for the photo cell

as well as the data send and receivers from the occupancy sensors and all other necessary data transmitters for the dimmer. Dimmers are having the capability for particular places for example areas with audio and visual demonstrations as well as through the entire the whole program to manage substantial services (Li et al., 2010).

Dimmer switches happen to be linked to a relay panel. Pre-programmed dimming settings from a relay panel offer predetermined dimming for many stations as well as loads. The preprogramed are actually tamperproof, which is, they would never let anyone with the exception of certified lighting control employees to change the settings and programs (DiLouie, 2008).

Dimming could be used to apply many energy savings approaches. For instance, lights could be dimmed when the need for electrical power goes over a predetermined rate, possibly within a standard load- reducing guideline. This kind of reductions are usually cannot be noticed via the majority of users (Li et al., 2010).

The good example can be mentioned on the florescent lamps, that throughout their life span, the quality of light and its level would be decreased.so that the job of the dimmers in this situation can be the light controlling of the florescent lamps and after that improving the life span of the lamps.

3.3.2.3 Daylight Harvesting

According to the demand for the electrical artificial lighting in different places the day light harvesting, reveal its potential to complement the artificial lighting, and increase the energy reduction. This system is possible in the corridors, hallways and generally all the places that have access to the natural day light. The ambient light sensors by controlling the light, they can complement the required light in every

place according to the day light and the artificial light of the area.by applying the manual or automatic shutters and blinds, controlling the sun light improves and so that the glare, direct light and even the temperature of the places can be under controlled, and the continuous and steady light in a space could be achieved. (Hui, 2017).

Appropriate daylight-harvesting design not merely involves offering sufficient daylight to a location although does therefore with no undesirable unwanted effects such as high temperature absorption as well as glare. Effective daylight-harvesting styles would integrate shading gadgets to lessen glare and extra contrast (Li et al., 2010).

3.3.2.4 Ballasts and Drivers Reference

In 2009, Robert Lingard suggested indicated, fluorescent and high intensity discharge (HID) light resources are not able to function without ballast. The ballast offers a starting voltage and limitations electric current to the lamp. In the same way, LEDs need a power source (frequently generally known as a “driver”). The energy source converts line (AC) capacity to the correct DC voltage (typically in the range of 2 and 4 volts DC for maximum lighting LEDs) and current (generally 2001000 milliamps, mA), and could also include supplementary consumer electronics for dimming and or color correction control (Zhang et al., 2011).

Currently available LED motorists are usually about 85% efficient. Therefore, LED effectiveness ought to be reduced by 15% to take into account the driver (Edirisinghe, 2012).

The energy level needed changes through the entire LED's temperature raises and as well, decreases. With no, the right LED light driver the LEDs would become as well-heated and unpredictable leading to failure and undesirable efficiency. To guarantee the LEDs perform the job properly the self-contained LED driver must supply a maintained continuous amount of capacity to the LED (Zhang et al., 2011).

The LED motorists provide security to the LED lights to prevent current and voltage variances. The drivers make sure that the voltage and current to the LED lights continues to be among the in use selection of the LEDs irrespective of changes in the mains supply. The safety prevents offering an excessive amount of voltage and current that could decay the LEDs or as well low current, which could decrease the light output (Wang et al., 2017).

The LED drivers will be either utilized externally on internally within the LED light bulb installation (Wang et al., 2017).

Internal LED drivers are generally found in domestic LED bulbs to create it easy when changing the bulbs; the inner drivers are often located in alike case as the LEDs (Wang et al., 2017).

External LED drivers are actually situated independently from the LEDs and generally used for applications for example outdoor, commercial and the roadways light. These kinds of lights require independent drivers that happen to be simpler and with a more reasonable price to change. In the majority of the applications, the manufacturer specifies the kind of the LED driver to make use of for precise light set up (Wang et al., 2017).

The majority of the LED light bulb failures are because of the failing in the driver, in fact, it can be simpler to replace or fixed the external driver when compared to internal driver (Guo et al., 2015).

To find the most effective sort of driver the current and so voltage mode is highly recommended. The LED drivers are possibly continuous current or continuous voltage (Guo et al., 2015).

The Regular current drivers give a fixed output current and could have a variety of productivity voltages. It can be mentioned, as a good kind of example a continuous current driver can be one with 700mA result current and with a result voltage selection of 4-13 V Dc drivers (Guo et al., 2015).

The continuous voltage LED drivers offers a fixed result voltage and an optimum regulated output current. They are sued to power led systems that want a well-balanced voltage of say 12 or 24 Volts DC. An average driver might provide 24V and an optimum output current of just one 04A (Guo et al., 2015).

According to the physical dimensions to make sure that, it fits in the region it really is to be fixed (Castellanos et al., 2016).

Additional criteria to choose the most beneficial kind of driver is to regarded as are the power factor, optimum wattage, dimming capability and the compliance with worldwide regulating specifications (Castellanos et al., 2016).

Finally, after the LED drivers, a power ballast is a gadget that limits the quantity of current within an electric circuit. In electric gas, discharge lamps just like fluorescent and neon lamps ballasts control the current moving throughout the light (Alonso et al., 1993).

Also two primary types of ballasts: magnetic and electronic. Magnetic ballasts make use of electromagnetic induction to make the voltages used to start out and function fluorescent lighting. They include copper coils that generate electromagnetic fields to regulate voltage. Magnetic ballasts, which were used in fluorescent lighting since their origin, are believed outdated and so are being eliminated by newer electronic ballasts. So that they are more energy conserving (Alonso et al., 1993).

Magnetic ballast has many issues regarding the control of the light, one of which is the issue of lamp flickering and humming noise. This issue stems from the fact that while magnetic ballast is able to control electricity current to the light fixture, it cannot adjust the frequency of the input power and thus causes eyestrain and headaches in people and the humming could be annoying. On the other hand, electronic ballasts are able to adjust frequency of the input power, therefore eliminating these complications. Electronic ballasts can also control several lamp fixtures which magnetic ballast are not able to do so.

There are three different types of the ballast for the florescent lamps that each one has its own special behaviors and capabilities. The first one Is the Rapid start ballasts which provide the sumualtainles voltage to the lamp fixture and makes the electrodes to be warmed up enough to start emitting electrons and in this process as much as the

electrons increase, less voltage is needed, till the cathode can be warmed up enough to start working itself (Hui, 2017).

The other type of ballast is the instant one that has the best energy performance due to its reasonable price.the functionality of it is by providing a high voltage to the lamp there would be no need for warming electrodes, so that by eliminating this process the lamp can start emitting within 50 milli second (Hui, 2017).

The system that can work side by side the HVAC program and the lighting control system to administrate the energy usage and cost, to increase the quality is the EPMS (Electric power management system) for controlling and monitoring the the energy distribution for increasing the quality of usage and utilization. Also tits existence makes sure that energy consumption is working and is distributed fluently in all the equipment's to get the best out of the machines, and no sag is in the energy distribution system (Hui, 2017).

3.3.3 Third Level: Grid Level

There are three different types of the ballast for the florescent lamps that each one has its own special behaviors and capabilities. The first one Is the Rapid start ballasts which provide the simulation voltage to the lamp fixture and makes the electrodes to be warmed up enough to start emitting electrons and in this process as much as the electrons increase, less voltage is needed, till the cathode can be warmed up enough to start working itself.

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3.3.3.1 Monitoring

The EPMS control and monitors the electrical loads of significant products. Inputs to the monitoring device could be current as well as probable transformers along with other sensors or monitoring products. Current transformers are accustomed to provide information regarding electric energy even while potential transformers are accustomed to offer information for electrical voltage meters.

mostly the models for monitoring are presets and are microprocessor based that can do the jobs of the screening, monitoring and the controlling, on the other hand some of the models can be used locally and have the ability to be installed within the EPMS network to control it. (Kuzlu et al., 2015)

The monitoring devices can be installed throughout the distribution devices and systems, to check whether there is a sag, the harmonic or interruption or any kind of problem that might cause the malfunction or quality decreasing in the system.so that

it has the potential to control the input for the distributing devices. (Kuzlu et al., 2015).

3.3.3.2 Electricity Usage Metering and Sub-metering

The smart metering devices, mostly consists of extra details and equipment's compare to that of the typical kinds of the metering devices, which in today's world that the costs and energy is playing an important, seems as a necessary device. The smart metering devices have the ability to control the usage, send, and receive the information to the local device, so that it can in the real time process control the price.

A power meter is a gadget that evaluates the quantity of electricity used by a specific place and area. To ensure that a computer program to accurately bill a person a meter is required to record usage. When billing a person, utilities record the electrical power usage along with the time when the electrical power was utilized, from the time the expenses can vary greatly during the day (Kuzlu et al., 2015).

Smart meters possess a large number of advantages over regular meters. Smart meters are capable to evaluate as well as, record interval information and statistics and connect the info to a distant area. Smart meters enable utilities to present different prices for electricity according to periods of day and the season that may be used to lessen peaks needed. Smart meters must locate power quality challenges as an example transient, voltage disturbances, power factors and harmonics (Kuzlu et al., 2015).

Real time pricing, also referred to as the dynamic pricing, makes better still usage of smart meters. Usage time prices are predetermined by the utility as well as, supplied

to customers, allowing the client to modify or change their load appropriately. Real time price range differences per hour, predicated on the utility's actual price of producing or as well as getting electrical power at that specific time. Having the ability to regulate energy utilization in response to these cost changes can save electrical power customers a lot of money (Ahmad et al., 2016).

Sub metering is so ideal for comprehension just how that energy can be used in a specific building or region. Utilities often use a single electrical power meter for a whole group of structures, which serves their reasons but will not offer any info details to the client on the electricity usage distribution between different areas or structures (Ahmad et al., 2016).

the CT or current transformer is a part of the sub metering devices that has the ability to collect the information over the voltage, wattage and also the amperage of a device which is attached to a circuit of a power panel in an almost real-time period, and if they are connected together, can have the ability to connect to a processor or a server to control and monitor the usage. (Ahmad et al., 2016).

The users can benefit from both the metering and Submetering due to the usage provision, so that the prices can be decreased and if extra energy usage is observed, it can be monitored and controlled. (Ahmad et al., 2016).

3.3.3.3 Power over Ethernet

Power over Ethernet gadgets could be phones, wireless access points, digital cameras and also the paging speakers or even cards readers and many others. Many main IT producers have applications for organizing capacity to the gadgets, both switching

them on or off and dimming the energy to the unit, much such as a lighting control system (Minoli et al., 2017).

The power over Ethernet administration software program mainly allows as well as, disables slots on a network switch. Using this method, a decrease in peak energy demand for this networks and the flexibleness for network managers to create different power intake for numerous IT gadgets. the power over Ethernet (POE) administration can be categorized as a part and element of the large administration network. The devices in an IT network that are controlled and monitored by SNMP for evaluating any kind of device, which is identified and is known through the MIB (SNMP: simple Network Management Process; MIB: Management Information Base). (Minoli et al., 2017).

In such respect, the LED technology makes the POWER OVER ETHERNET in order to give electrical power for the lighting program.

3.3.3.4 Occupancy Sensors

Occupancy or movement sensors can be products and gadgets, which sense the existence or absence of users as part of their monitoring range. In contrast to scheduling controls, occupancy sensors usually do not perform on a period schedule; they simply diagnose whether an area is occupied. They might be made use of in restrooms, utility rooms and in meeting rooms or coffee areas and several other areas and places. In most cases, the sensor as well as, a control device could be enclosed in a single unit, like a wall box, but also for larger services, the sensor should be linked with a relay panel (Chew et al., 2017).

The control device unit and the relay can be developed and set to turn lights “on” whenever the existence of people can be noticed via the movement detector, and could be programmed to turn the lighting “off” any time the area can be empty and unoccupied to get a predetermined period of time. The level of sensitivity of the sensor can be also modifiable (Chew et al., 2017)

There are many types of movement sensors readily exist, which includes passive infrared (PIR), active ultrasound as well as hybrid technology systems, for example a combination of PIR and active ultrasound, just as well as PIR and audible sound. The mentioned sensors are usually applied in places as an example hallway, personal offices, conference and meeting rooms or bathrooms, and storage space environments (Chew et al., 2017; Labeodan et al., 2016).

the ultra-sonic sensors by sending high frequency sound waves and sense the reflected waves due to their return to the original device, can function according to the movement and adjustment of the waves. The benefit of this kind of sensor is its coverage in an expanded area, like classrooms or large meeting rooms. On the other hand, disadvantage of this sensor is its inability to function in the areas that there is vibration that sound and noise is created, like the HVAC devices while are working can cause the sensor to be misled and turn the lights on. (Chew et al., 2017).

PIR sensors identify radiation, which can be, the heat energy source which could be released by bodies, which is called “passive” due to they just accept infrared radiation, nor release a single thing. PIRs run in a type of sight and have to “see” a location, so they cannot become blocked by open area partitions as well as high furniture. PIRs make use of a lens to target heat energy in order that it could possibly

be detected. Nevertheless, the lens sights the covered region through multiple beams or cones and could create protection gaps. Any items that avoid the sensors from "seeing" portions of its designated region may cause the sensor to believe that the region is unoccupied and convert the lights off, even though it is not (Chew et al., 2017).

Careful keeping occupancy sensors must prevent fake alarms. Occupancy sensors could never be installed in direction of windows. Even though the infrared wavelength to which the chips happen to be delicate and sensitive will not pass through glass good enough, powerful source of infrared like a vehicle headlight or sunshine reflecting from a car windows has the capability of overloading the chip by infrared energy to mislead the electronic devices and induce a fake alarm. A person walking on the other side of the glass nevertheless could not normally be "seen" by these tools and devices (Chew et al., 2017).

Devices is better not to be installed in in the places in this regard, an H VAC vent would blow warm or cool surroundings onto these tools surface. Although environment atmosphere has very little emissivity (releases small levels of infrared energy), the atmosphere blowing on the plastic-type material window cover could alter the plastic's heat range enough to mislead the electronics (Labeodan et al., 2016).

To increase the productivity of the occupancy sensor that is sound base, additional kind of technologies are helping for this importance, such as the hybrid ones that are mostly the combination a kind of sound base sensor such as ultra-sonic sensor with the PIR sensors (passive infrared). In this manner, the sensitivity and the precise

detection of the occupancy would be increased and the false detection decrease in a considerable amount. (Labeodan et al., 2016).

placing the occupancy sensors on the wall or the places that has the best coverage over the working area, or using multiple sensors in the places with irregular shapes is one of the most important factors in detection of the occupancy. This importance reveals its most necessity in the critical places such as the staircases or in the spaces with a critical function that the regular periods of light is not necessary. (Labeodan et al., 2016).

3.3.4 Forth Level: Communication and Sensing

The network layer routes data packets through the network. It deals with network addressing and determines the best path to send a packet from one network device to another. The Internet Protocol (IP) is the best example of a network layer implementation.

3.3.4.1 Wireless

An effective alternative for cable connection is the technology of wireless, while wireless technology may not provide bandwidth as fast as physical cable connection, it can provide mobility and is an excellent choice for older buildings where physical connection is not possible due to lack of pathways and physical links. The wireless technologies is therefore ideal for implementation of smart building systems including Wi-Fi and an emerging technology (Bahga et al., 2014).

3.3.4.2 Wi-Fi Mesh Networking

In a wireless mesh network, every node as well as WAPs happen to be connected with each other wirelessly rather than using wires cables for connecting wireless antennas. Often these “hot spots” are manufactured using omnidirectional Wi-Fi

particular sort of antennas. Directional antennas using Wi-Fi happen to be after that used for connecting the hot spots and nodes as well as, make the mesh.

in the mesh networks the nodes can identify each other and do the adjusting themselves... this effect is the extended cover of the Wi-Fi in the overcrowded places as well as, around problems and interference. Mesh systems offer redundancy and "robustness" due to the capacity to balance network traffic (Bahga et al., 2014).

3.3.4.3 ZIGBEE

A wireless standard technology that benefits from the frequencies, which are not, identified (900 MHz and 2. 4 GHz) for low data rate systems. It is best used for the residential or commercial smart buildings that the rate of the data transfer is not very high, and is mostly used for the control switches, such as off and on or open and close commands. One of the benefits of using this technology is the energy efficiency of the device that uses a very typical kind of battery, and the scale ability of the system that the number of the devices can be used in the system of a building. (Kumar et al., 2017)

3.3.4.4 Communications Protocols

In a system, protocols are the assigned rules that are making the format of the data transfer between or within the network and the devices, in a specific rate of data transfer as well as the encoding and decoding of the information, its speed and etc. (Mendes et al., 2015)

3.3.4.5. Ethernet

The standard technology development is for all the things to be component of a node on a cabled or wireless Ethernet network and also have an IP address. This can be

actually the digital convergence pattern which has already experienced and can continue to see for a long time to come (Mendes et al., 2015).

In the info telecommunications arena IP and Ethernet have already been requirements for a long time. Building automation systems have specific sector protocols (BACnet, LonTalk and others), however they too are going to convert or user interface the protocols to the general, dominant IP protocol (Mendes et al., 2015).

3.3.5 Integrating Smart Lighting Solutions

There are three main elements in determining advantages of smart light systems over traditional light systems, first and foremost is the fact that they are undeniably efficient. By implementation of smart lighting systems, energy consumption can reduce drastically in which it returns up to 70% cost savings in contrast to traditional technologies which barely bring any cost saving solutions. The same percentages in cost savings can be expected in carbon footprint of smart lighting systems.

The second element can be noted from the improved administration perspective. Because of the incorporation of communication and electronic systems, the ability of manipulating the color of the light, direction of the light beam in the space and the strength of it with the new lighting system design can provide a wide variety of advantages. For instance, outdoor implementation of smart LED technology, to light poles and other forms of streetlight, makes roads safer and more visible to pedestrians and automobiles regular commute, and in reduction of excessive light pollution in outdoor settings. In regards to indoors lighting, implementation of smart LED technology has shown improving human performance in firm conditions and supports in enhancing the act of space settings and activities taking place in smart

LED controlled environment. The third elements are implementation intelligent controls which enables the LEDs to vigorously modify lighting amounts responding to exterior circumstances and can achieve a high level of energy savings measuring up to 80%. (Shelby et al., 2012)

In addition, the other one can be evaluated from the durability angle and perspective. LED light systems can have excellent longevity and life span which can be ranged from 50000 to 100000 hours under normal conditions. This amount of lifespan could be even extended by the implementation intelligent control systems. (Shelby et al., 2012)

By the way of individual switching, smart light systems have a significant advantage over traditional light systems. The degree of controllability and management of any light is by far more superior to traditional light systems, any user groups or individual can have access to specific control management interface to adjust and maintain smart lighting systems remotely regardless of their physical presence in the building, this way of management can be done even if they are way farther from the actual system even in outdoor environment. This fundamental feature opens up a broad range possibility to control lighting formations, referred to as lighting sections allowing a variety of lighting environment and configuration based on what activities taking place in any environment. Upon this method, the approachable style of diverse lighting moments for implementation of certain presentations or actions permits developing proper atmosphere simultaneously that fulfills comfort and ease of the end-user (Castro & Skarmeta, 2013).

The adoption of smart control to the light management system provide a better ground work and foundation for maintainable design and lighting organizations, for example a green and power efficient building can be operated and monitored constantly by the use of smart control system which provide efficient operating mode and proper behavior adoption with respect to the interaction of physical environment to the whole system. Among other benefits, the power of the system is ideal for minimizing energy intake and reduce costs by the use of more efficient style of process sensible of what is happening in an actual level (Shelby et al., 2012).

Among other essential benefits, the capacity of this type of smart organizations for power reduction usage and equilibrating operative prices because of more effective practice based on actual energy needs and the behavior of the user involved. (Castro et al., 2013)

Furthermore, because of high integration of wireless technologies, more benefits can be achieved, like a decreased system price (financial and difficulty involved), and a far more elastic arrangement by use of Wi-Fi adjustments and sensors systems which may be managed and checked distantly with no requirement of straight social being involvement.

Smart Light structures (for control and administration) may offer abilities to immediately work a gadget or couple of them in broad setting of firm conditions. (Castro et al., 2013)

By sequential and cosmological arranging, it can be done to pre-programmed devices for handling lighting and its patterns throughout a concrete time. It also has the

ability of adjusting the procedure of the system based on variation of the sun position throughout the year. according to environmental and individual behavior point of view, by the design as well as, positioning of Smart Light structures in a real atmosphere, it is achievable to adjust performance of procedure based on performance of checked things and factors of desire for an actual circumstance. For instance, area or streetlamps could be measured predicated on data recovered by installing movement or movement devices.

For real Occasions programming it can be probable to require particular outlines for firm circumstances for example vacations, nights, or real dates where certain type of different lighting is essential or suitable based on diverse necessities. (Castro et al., 2013) also one of the most important aspects can be the alarm conditions, in which the safety might possibly be also upgraded by the incorporation of the kind of smart structures which may embrace processes for example doors opening and light by recognition of feasible attentive scenario (Castro et al., 2013).

According to the complex System Logic or Intelligent Inference, event-based settings or design recognition might possibly be applied as an improved act of something which must adjust its performance within instinctive technique based on internal and external variables standards predicated on if-then-else declarations, rational operatives or progressive form reputation procedures.

Concerning to Smart Grid is especially appropriate, precisely, while discussing incorporation of power systems as well as information and conversation technology (ICT), providing them with hitherto untapped capabilities to be able to attain

unprecedented improvements in this kind of essential areas as their efficiency and reliability (Khatoun & Zeadally., 2016).

Smart Grid (A smart grid can be an electrical grid with a selection of operation and energy actions including smart meters, clever appliances, renewable energy assets, and energy conserving resources. Digital power conditioning and control of the creation and distribution of electrical power are important areas of the clever grid) is an integral component as incorporation of clever structures; it may be imaginable to create and accomplish in far more effective way, any type of manufacture and spreading program. Concretely talking about light structures, these are probably most essential energy obligations of metropolitan areas and big constructions. As a result, it really is a part to be looked at prior to guideline of usage based on condition of grid, conservational circumstances, schedules and well-being requirements (Khatoun & Zeadally., 2016).

To the end, terms for example environment transformation, reduced amount of carbon footprint, global warming and renewable energies had already been becoming more prevalent in daily life. There exists universal consciousness which supports a technical modify to eco- effectiveness, also among the solutions to realizing, this rather modify passes over renovation of progressively old-fashioned electricity spreading systems. It really is at this point where in fact application of systems involved in web of Things market traces its highest level, allowing integration of the networks of independent components in a position to communicate and connect to others, refining group organization in together, hence obligate them becoming better (Castro et al., 2013; Khatoun et all., 2016).

3.4 Chapter Summary

Due to the impacts of the light on the human behavior and health, the smart light has shown its capability for helping and improving the human health by adjusting the light to the most optimum light desire. Generally, this technology is consisting of four parts that they can be combined and interact with each other. The first level is the light source, which in the previous chapter had been explained. The second level is system level, third one is grid level and finally the fourth one is the communication level. In all this levels the combination of the light source and the electricity distribution and data communication is considered in different forms like wireless or using electricity I different ways is mentioned, and finally the monitoring and controlling them is mentioned and discussed. All this phenomenon's can be used in many different stages from very simple levels like the residential smart bulbs (which is a package of smart light in the form of a bulb) to extremely complicated and professionally levels according to the demands, so that in the next chapter by help of the case studies the usage of the smart light in a few common places is mentioned.

Chapter 4

SMART LIGHTING EXAMPLE STUDIES

Smart lighting is used in many different spaces and areas in built environment, most common usage of smart lighting in nowadays will be categorized in different scales and levels, in this chapter are going to be mentioned as examples and case studies which are done by the international companies that the pioneers in this field.

From urban to building scale and from office to residential functions of buildings are some of most common kinds of the places that can reveal the real potential and differences that the smart lighting is capable to provide the satisfaction in the health issues.

The most common thing in this regard is the flexibility and the compatibility of the objects to work and match with other control systems, such as smart phones, tables and personal computers, that have the responsibility of controlling the smart objects which in this regard is the lighting source.

4.1 Methodology

In this chapter set of examples are provided from the companies' web site by trusting to their loyalty to the provided information from them. To clarify the benefits of using the smart lighting in different kind of buildings and scales.

The examples are selected according to the most well-known companies that are mostly the pioneers in this field. In addition, in all the examples, a new kind of technology in the smart lighting manner is introduced and the beneficial result of them according to the companies is mentioned. The examples in different categories are varies, so that the ones which are selected, are from the categories that almost every person has experienced one of the spaces.

In the residential category, the usage and the complexity of the smart light and the system smarting is not as complicated and complexity of the other categories. In the residential buildings mostly the objects, such as lamps are designed as a smart object, which can work can combine and work with other smart objects in the area, or function individually without the existence of the other smart objects. The best example in this regard can be the Philips hue bulb, which can be mixed with other accessories in this category, or be completely independent from the other smart accessories.

4.2 Example Studies

4.2.1 Bagheria, Italy

Bagheria is a city near the Palermo which was a beautiful destination for the holidays for the nobility of Palermo in the 18th century who had wonderful villas. The location of the Bagheria in the map can be seen in figure 9.

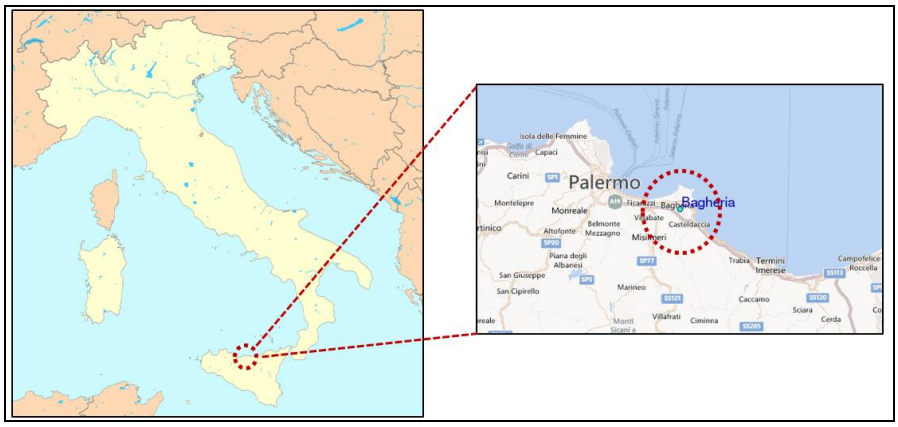

Figure 9: Location of Bagheria (Google map, made by author)

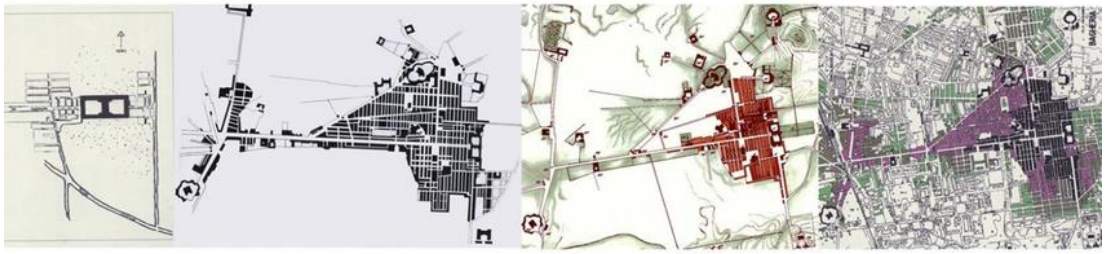
Figure 10: Urban Development of Bagheria from 1700 to 2000 (Elejoste et al., 2012).

This work is certainly concentrated on the valorization of the primary historical pathways connecting the system of villas.

The project is certainly analyzed from several perspectives. Initial, all technical factors linked to the light and energy aspect will end up being acknowledged. Eventually, an evaluation of the feasible benefits linked to smartness and sustainability improvements would end up being presented.

Due to the Condition of the light system of Bagheria, this region is definitely evaluated from many points of view. In regards to city illumination and lighting of every roads and pathways a set of survey is done. The contribution of every different luminaire in Bagheria as of today are determined with the means of survey conduction.

Concerning the luminous flux control, through the first hours of night, the power reaches to the maximum level and is defined at 220 V, which is reduced at 22 p.m. After mid night, the flux is leaner and can be defined at 190 V. Again, the power raises about 4 a.m.

Because of the lighting control program in 2011, the 3 % energy saving was reached. It had been done on forty- five switchboards (5 in the project region).

Due to the lower standards which is exist in this area, and the high amount of energy consumption in Bagheria, the new technologies had to be applied and even designed.

The work for the latest kind infrastructure adopts the most effective lights (such as LEDs) and control systems like light switch to lessen power intake, improve the buildings and road light outstanding. Aside from that, with a multi-usage of road luminaire, additionally, it can be ideal in the combination of ICT to produce a practical network for most functions.

In this project, new techniques and technologies are introduced, that one of them is the stair light. This technology lets the designers to have the flexibility of applying many different desires just in one stand. It is applied in different heights to gives the different kinds of needs according to the place and time and the necessity of the activity which might be held in the area.

The lighting source in stair light is LED, which was chosen for its qualities, high-energy savings, lifetime, very limited ultraviolet and infrared emissions, limited environmental effect, ability to be dimmed and immediate off and on switch ability.

Also due to the usage of the Led it has the potential to show the necessary information according to the place, and it has the potential of tilting and controlling the traffic according to the sensors and the given programs from the municipality control room. The touch pad screen of the stair light makes it capable to communicate with the users in different ways. The benefit of using of the stair light is the RGB LEDs, which lets the lights to have different kind of light and color temperature in different times according to the needs, for example in summer the cool colors can be applied and in the winter the warm ones.

Internationally, the goal and plan mounted power is usually equivalent to 3200 kW. As stated before, prevailing control system can be dependent on a fixed power control at night time, from midnight till to 5 a.m., the power can be usually decreased to 67% of the minor worth. Total approximated energy cost savings can be 15 %, containing a correspondent of around 3800 working hours each year.

If a trusted info system has been made, a smart control system predicated in Wi-Fi or power range interaction can be done. The light program could be run based on the light and environmental circumstances. Each fixed object may notice many related features, for example, solar luminance or existence and actions of automobiles or people (Elejoste et al., 2012).

The cost and the pay back of the project costs can be done in 5 years, due to the mass production of the stair lights and the LEDs in the city, and the much lower and reduced costs of the energy consumed in the city by using the recent smart lighting technology. The new types of light sources and by applying the sensors to dim the light during the time that the high illumination is not necessary, and the help of the

control system for lighting and traffic control can reduce the costs reduced drastically.

The repair light proposal contains the houses in town of Bagheria. 6 houses were selected as cases for research. These structures were made to enhance the moment feeble light of the houses. This task characterizes a simple have to create the houses ideal for appropriate usage by vacationers. Therefore, the power usage of the lighting systems isn't weighed against the energy usage of the prevailing lamps.

Distinct situations can change changing on and off for a number of groups of lights. So, site guests may differentiate among various stages of building.

it might represent the initial large- level showing of multi-usage system in southern of Italy consuming alone a related effect on power intake for civic light, excellence of light atmosphere and visitor’s protection, supporting of residents and tourist flexibility, location and several various possible welfares which might stop from utilization of in-area devices, a conversation system and principal digesting of info.

4.2.2 OSRAM OS headquarters - Regensburg, Germany

In this project the headquarters have tried to find solutions to improve the health quality, and one of these innovations is the human centric lighting (HCL).

Due to the company claims according the dynamic lighting which has the potential to control the color temperature and light intensity has the benefits of providing the improvement in the circadian rhythms, also giving the sense of relaxation and productivity at the same time, improve the immune system of the body, helping the workers to concentrate better, and improve their mood and etc.

For the project, approximately 3000 control devices meant for light sources also around 350 sensors and many KNX switches have been applied. Also it should be mentioned that the HCL is improved for this project in the way that light can be between up to 500 lx, and also the white color temperature can be dynamically adjusted from 3000 to 6500 K, and and many more feature like real time controlling in different options.

To achieve the mentioned features and many of the other options in the system the company has used a powerful software program to give the best control over the light to the users and the software has the potential to control all the switches and adjust the vest light performance according to the light and activity.

Furthermore the general lighting also can be considered into account, so that the LED and their drivers are designed in the way to provide a constant optimum light trough out the day to reduce the fatigue and improve the concentration, and in this importance the light intensity and its color temperature gradually would be changed from the morning to the afternoon. The light intensity might be changed from 500 to 800 lux during the day, and the program considers the seasonal light behaviors. By considering the provided features in the building, it should also be mentioned that the energy consumption and its costs are not put aside (retrieved from https://www. osram.com/ls/projects/headquarter-osram/index.jsp).

4.2.3 The Edge – Amsterdam, Netherlands

CBRE is proactively controlling The Edge in the city of Amsterdam, the world's greenest & most intelligent workplace. With an enhanced method of management of the property, cutting- advantage systems and proprietary data analytics, as it was mentioned that a more sustainable and smarter place is created.

The top type of the job may be the Property administration of a 40000 square meter workplace, which usually obtained the best sustainability rating of any project ever sold.

Table 1: The Edge Building Information (Drawn by Author)

The Edge	Location	Amsterdam, Netherlands
	Client	Ron Bakker, Lee Polfsano, PLP Architecture, OeverZaaijer
	Architects	Babette Bo u man, Laura Atsma, Rkk Rijksen, Fokkema ft Partners
	Lighting system provider	Philips lighting
	Area	40000 square meter

The Edge is usually certifiably the cleanest & most connected large work place in the world. Created for the global financial company and main commonly Deloitte, the Amsterdam skyscraper legally opened up in the center of the economical center in 2015. The Edge provides a drastically latest operating environment, earning after that it the best BREEAM new building rating ever documented by way of the Building Study Establishment (BRE), the universal assessor of sustainable structures.

The project building combines a range of intelligent technology and adjustable job spaces to motivate cooperation and enhance sustainability. Several 6000 Ethernet-powered, LED connected lighting evaluate occupancy, motion, lighting amounts, humidity, heat, and temperature on a continuing basis. Every employee is capable of connecting to the building with a smartphone application software to look for a parking space, customize heat and temperature and also light within their working area, record their improvement in the building's fitness center or find an open up desk (retrieved from http://www.lighting.philips.com/main/cases/cases/office/edge).

4.2.4 German Heart Institute – Berlin, Germany

The German Heart Institute which is in the city Berlin is certainly a lifesaving center. Every year it performs around 3000 open heart surgeries and also a lot more than 1500 additional surgical treatments. With patients frequently in essential condition, the institute looked for a fresh approach to increase treatment on the wards.

Table 3: German Heart Institute information (Drawn by Author)

German Heart Institute	Location	Berlin, Germany
	Client	Prof. Roland Hefzer, Thomas Michael Hdhn, MRBS Architekten Berlin
	Architects	IBP- Pilz & Partner
	Lighting system provider	Philips lighting
	Specialist Electrical	Philips Lighting, JuLiane Lokat
	Lighting Consultant	Armin Mross

The staffs specially the doctors who are working in German Heart Institute realize the need for light when intensive restoration was completed at the capability, these were searching for a advanced, controllable lighting idea that could help affected person recovery. Not merely could this try to make it simpler for crew to provide medication, but impressive light has been demonstrated to get a positive influence on stress, rest and specially the sleep patterns and hormone secretion.

Philips HealWell was in fact instantly recommended. This patient area Lighting program has been made to support natural sleep patterns and rhythms via simulating the day light patterns outside. Once patients go into hospital, they often times have trouble sleeping, that may have a poor impact regarding their wellness and mood. Not merely does HealWell help with keeping their sleep patterns regular, although

Light hues could be transformed at the patient's command, and the system conforms to all hygiene rules.

In the individual recreation room, additional ease and comfort originates from luminous textiles. The kind of amviance which can relax and soften audio. The new light systems are assisting the Institute to supply better look after patients, and an improved working atmosphere for workers. Precisely what the doctor requested.

Every patient can control the light within their room via handy remote control, using preferred colored configurations. This gives them a larger feeling of control, and an elevated sense of wellbeing.

Patient area HealWell is specially created for Developed to donate to people visual, psychological and biological response to light, HealWell creates a distinctive environment that supports affected person wellbeing It is made to support the biological clock of sufferers. In a field research we tested this alternative, and the effect was that sufferers in HealWell rooms in fact rest 8°o longer and need a shorter period to fall asleep. Furthermore, the ambient light is certainly personalized by using predefined settings that could be controlled by the individual themselves.

The HealWell lighting program addresses the requirements of sufferers and medical staff Powerful light is used to supply an automated day-rhythm, which mimics the various patterns of daylight. Simultaneously, it offers medical staff the chance to overrule light configurations, to have great working light circumstances the time the problem requires so, for instance with examinations or emergencies.

It addresses the various requirements of its users all the time, night and day (functional, psychological, biological), using a smart networked control system

Also it offers a pleasant atmosphere that may be controlled with patients, and also superb working light for personnel. The effect has proven remedy, with proof improved satisfaction, improved rest duration and rest on-set latency and improved mood. The applied as a turn-key solution, including lighting style, installation and teaching for staff.

The Heal Well solution range from the following elements:

- Dynamic white-colored light: ceiling modules offering daylight rhythm with different light amounts and warmer or cooler light, along with simple exam light for staff
- Ambient light: LED based colored light range in cove opposite the bed, that may provide orientation light during the night.
- Reading light.
- Patient control: offering choice for the individuals of 3 pre- arranged light colors for the cove, along with reading light dimming control (Retrieved from(www.philips.com/healthcarelighting)

4.2.5 Primary School Eriksbergsskolan, Sweden

The light criteria in educational organizations for Sweden are totally provided. As a result, the task firm Let It Light chosen collaboration through a versatile partner. SLE presented answer which gone beyond goals and aided to make performing and motivational space with optimum circumstances for education. However, in past couple of months LIL in cooperation with SLE had done a large number of very

much the same jobs, for instance in Uppsala, twenty classes in Bracklosaskolan, 20 classrooms in Tunabergsskolani, 25 classrooms in Soraskolan, 4 classrooms in Saterskolan in Sater, 2 classrooms in Kristina Gymnasium in Falun and 8 classes in a college in Kiruna.

Table 4: Primary School Eriksbergsskolan information (Drawn by Author)

German Heart Institute	Location	Uppsala, Sweden
	Lighting Design	Let It Light (LIL)/Rexel
	Project Manager	SLE studio - Michal Elecko

For light of classes and various other education places, utilize lighting resolution Contemporary Light in Colleges. LED luminaires are made usage of shed light up and down.

Luminaires found in Sweden certainly have been a customized edition of traditional straight and unintended postponed luminaire. They consume apparent outlines, dimming with prismatic diffuser, color-rendering directory that is in accordance by way of EU rules for interior workplace areas.

In Erilsbergsskolan, the company has transformed the lighting program in ten classes. Regular Swedish classrooms are around 72 square meters huge and 3 meters high. Aiming to attain at slightest 500 lux on desk area.

Old system in a single class contains different sort of fluorescent lamps. In the brand new system, the company has utilized LED luminaire equipment, which preserved around 45 % on power usage. Extra 2 LED luminaires had been consumed for upright lighting of the whiteboards that preserved 31 % on power usage. Blackboard

luminaires had been particularly attuned so possible stare becomes completely removed and regularity becomes sustained at very continuous stage, I. e. there will not be any shades or dark zones when dealing with panel. Entire cost funds with LED luminaires in a single class stayed 44 % (excluding the investments that have been supplied by the lighting organization program).

The lighting organization program implemented in Eriksbergsskolan employs daytime and movement devices. Daytime strength device arrangements up perfect light stage, regulating it relative to available daylight, while gesture sensor really aids to conserve power when no motion is usually noticed in classes and changes the complete lighting structure off instantly during disruptions and following the lessons are over.

Cost savings on power outcome not merely in savings on procedure expense, however, on conservation expenditures as duration of foundations have been extended by operative only use when wanted.

Institution in Uppsala is currently able to arrogance itself using one of very most modern light structures between European colleges. Moreover, countless cost savings on money and energy, LIL in collaboration with SLE produced finest possible lighting circumstances for an education place. Ideal light increases the period of consideration, improves capability to focus and effort effectively. In addition, Mr. Micael Ostlund, Technical Supervisor of institution, believes that class's appearance a lot diverse. Modification in excellence of light is usually evident at first view and I dare to state original system is usually unique with aged lighting (retrieved from https://projects.omslighting.com/references/primary-school-eriksbergsskolan/)

4.3 Chapter Summary

According to the provided examples, the energy usage reduction and the improvement in the human satisfaction is mentioned. Also it should be mentioned that the examples are showing the importance of the light source which in this regard is the LED, due to its potential to be used in clustered or linear form, and also the latest kind of the RGB type of it has given the potential of controlling the light color temperature according to the needs and place, and finally the limited energy consumption compare to other light sources has shown the benefit of using this light source.

Chapter 5

CONCLUSION

Due to the importance of the artificial light in the human's life since the stone age, is that the fire was discovered by human and let them to brighten up the night, until the recent last centuries that the flame operating lamps that work by fuels such as oil, gas was in use, and finally by the discovery of the electricity potential, to create light the artificial light entered a new era.

By the rapid expansion of the technology in different areas, and combining them together, the new and sustainable systems are born. One of the newly provided kind of technologies is the smart light. Although it might sound very simple at the first glance, it is consisting of many different kinds of technologies from the hardware and software branches.

Simply the smart light is consisting of the lighting source and the systems of lighting, monitoring and managing. Each of the systems can be combined with the other one or even be simplified to a compacted package due to the importance of the using place. For example, the one, that can be used in the bedroom, should not be necessarily as complicated as the one, provided in a hospital.

One of the technologies that can be mentioned in the smart lighting design, and has improved the light quality and in this regard is the solid-state lights that the most

common one of them is the LED. This source of light due to limited energy consumption, almost no heat creation and its quite long life can be very cost beneficial. The other factor related to the recent type LED technology is the ability to provide the RGB (red, green and blue) colors that in this regard it can provide the white light whit different color temperatures, so that in different times of the day and year there would be no need to change the light source or ignore this useful feature of light. Furthermore, the dimming possibility of the diodes should not be underestimated.

The other beneficial technology, which is improving the smart lighting, is the sensors in different areas according to the usage of the space. The infrared or video movement detectors and many other kinds of the sensors have given the ability to the system that not just the energy consumption has decreased in a considerable amount (for example the motion detectors in the corridors and toilets), but also for some special tasks and places it has improved the comfort for the workers (like the task light).

Finally, the management and monitoring of the system that can be very precisely programed and controlled by the wireless technology over the internet. This feature has given the smart light the possibility to be controlled and monitored from the places that might not have the fast or proper accessibility, the best example in this regard can be mentioned in the urban scale, which all the lights even in the crowded areas can be accessed from the control and monitoring room where most of the times is placed in the municipality.

As the examples have shown in every place different kind of design can be provided, and each of them has its own potential to improve the life quality and health. in office environment according to the need for specific amount of light in different areas such as the general illumination that should be 300 lux, and also do to the necessity of need for higher or lower illumination in the same space due to the desire for different activities, the smart light would show its great ability for adjusting the light according to the desired activity. In addition, more importantly, its power and potential to adjust the light for task lighting according to the need and desire of the employee, such as his/her age or disability, which might demand for more illumination.

Also in the medical spaces, the healing speed of the patients, and the ability of doctors and nurses to control the required light without disturbing them, and also the flexibility that this system is providing the patient to adjust the light desire.

In addition, the educational centers by dividing the classes in to different zones according to the movement in an area and its importance would be divided in different zones, and each one would be provided with a proper light.

By considering all the collected data in all the chapters, the energy reduction and the user's satisfaction is obvious, and also according to the mentioned information in chapter two by applying the smart light in many places, decreasing the negative and increasing the positive impacts of the light (especially for photo sensitive people), such as decreasing visual discomfort, or hormonal secretion related to light would be achieved.

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