Interim Report

Modular LED Lamp

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1.Acknowledgement

2.Glossary

Abbreviation	Description
EPS	European Project Semester
ISEP	Instituto Superior de Engenharia do Porto
USB	Universal Serial Bus
LED	Light Emitting Diode
UV	Ultraviolet
IR	Infrared light
WIFI	Technology that allows an electronic device to exchange data or connect to the internet wirelessly using UHF radio waves
AC	Alternative current
DC	Direct current
LLM	LED Light Module
LCD	Liquid-crystal display
NIST	International Guide for the use of the International System of Units
MD	Machines Directive
ISM	Industrial, Scientific and Medical
AFH	Adaptive Frequency-Hopping
RGB	Red, green, blue LEDs (Light Emitting Diode)

3. Introduction

3.1 Presentation

"Coming together is a beginning. Keeping together is progress.
Working together is success."

Henry Ford

There is five members with different background in project team, who successfully work together, share their knowledge and contacts in order to achieve the goal, which is Modular LED Lamp. In the following, there is a Figure 1, where are our pictures, names and home countries to give a better visual overview of us.

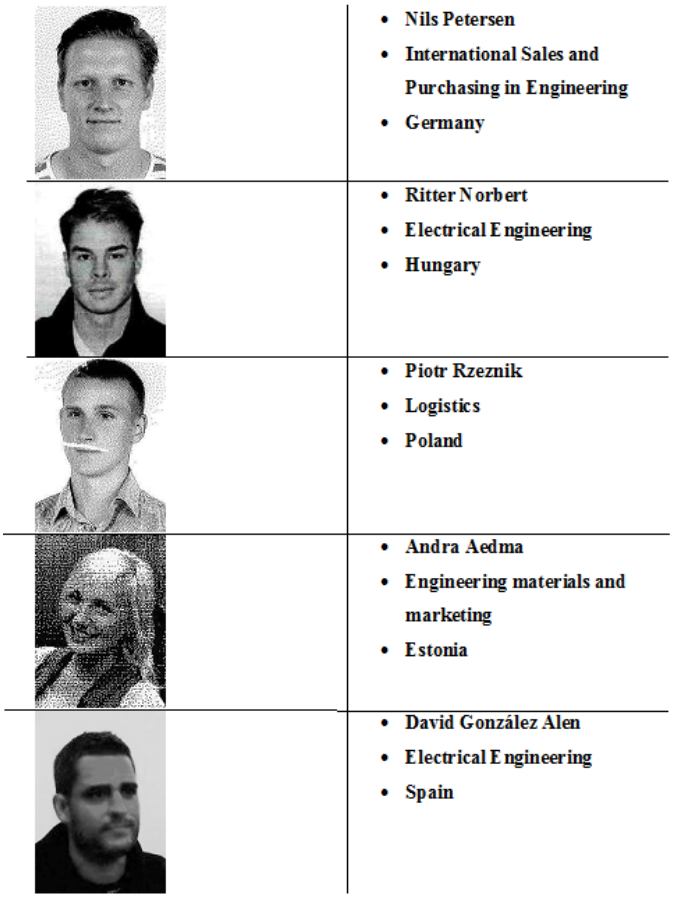


Figure 1: Team

1.2 Motivation

There were 15 proposals to choose. At first authors were thinking about Travel Logging System and Clicker Voting System, but found that needed knowledge of these

subjects was missing, so it was necessary to find new project. Looking through the proposals again, there were Modular LED Lamp which matched a bit with some team members knowledge and studies. Also it seemed to be interesting thing to do, cause for the last hundred years, the incandescent light bulb has been part of our daily lives. Today this humble invention is facing obsolescence due to global government regulations mandating increased energy efficiency for lighting. In an incandescent lamp, less than 10 percent of the input power is actually converted to visible light. The rest is non-visible infrared and heat, so incandescent lamp is not efficient. We have to search other alternatives, like LED which came in the markets five years ago, because of dramatic efficacy improvements in the technology [1]. LED lamp is worth to develop, cause it has long lifetime, durable quality, zero UV emissions, design flexibility, light disbursement, low-voltage it is energy efficient, ecologically friendly and operates in extremely cold or hot temperatures.

1.3 Problem

In past and even in present incandescent lamps are very popular. Positive side of these lamps is that they are cheap, put there are more disadvantages than advantages. For example incandescent lamps have low efficacy. For an incandescent light bulb to work, electrical energy has to pass through a filament for it to be converted to heat. It is when the filament becomes hot enough that light is produced. Since this process generates more heat—about 90 percent of its output—than light, a great deal of electrical energy is wasted. Also they have negative impact on the environment. Environmental lobbying groups have labeled incandescent light bulbs as harmful not only because of the electricity they waste in producing heat, but also because of the substantial amounts of carbon dioxide they emit. Thirdly incandescent lamps have short lifespan. The lifetime of a standard incandescent light bulb can range from somewhere between 700 to 1,000 hours. This means that, if used regularly, it will burn out in less than a year. Furthermore, incandescent lamps in general are vulnerable to vibrations. It means that we need some kind of alternative to replace incandescent lamp. LED lamps seems to be good solution of that problem. According to this project, Modular LED lamp has to build which has to be compatible with actual lamps, to be compatible with present day lamp bushings, it should be possible to replace only one LED at a time in order to have a real low cost and long duration, give different color tones to the Light bulb and to the environments where it will be used. Of course it should have low cost. [2]

1.4 Objectives

Design, and prototype development of a Modular LED lamp should be compatible with actual lamps The idea behind this project proposal is the development of a “Light Bulb” that is fully constituted by light emitting diodes (LED). The set of LED should be assembled in this “Light Bulb” in such a way that it is totally compatible with present day lamp bushings, either mechanically and electrically. Furthermore it should be possible to replace only one LED at a time in order to have a real low cost and long duration “Light Bulb”. This implies that there should be an easy way to detect which LED is damaged and an easy way to replace it. Considering the design, it could be possible to assemble all LED of the same color or having distinct colored LED in order to give different color tones to the “Light Bulb” and to the environments where it will be used. The geometry of the “Light Bulb” could also vary, according to the target market niche that is intended to attain.

1.5 Requirements

Requirements to LED lamp which we have to consider while developing our project:

- Fits to universal lamp socket (E27);
- Change colors with remote control (radius 10m);
- Easy construction to change the LEDs;
- Include an automatic brightness control system (maximum radius 4,5m);
- Reuse provided components or low cost hardware solutions;
- Use open source and freeware software;
- Adopt the International System of Units (NIST International Guide for the use of the International System of Units);
- Be compliant with the Machines Directive (MD), Low Voltage
- Directive (LVD) and Restriction of the use of certain Hazardous Substances (RoHS) Directive.

1.6 Functional Tests

Tests which are necessary to carry out of the completed LED lamp prototype:

1. Have to try does LED light bulb fits to E27 lamp socket
2. Have to try remote control. For that it is necessary to connect light bulb with a grid and when turning the button of remote control light bulb should change colors (in 10m)
3. Have to try take out some LEDs and replace them by another LEDs. Also have to connect light bulb to the grid to see if changed LEDs are working.
4. Have to connect light bulb to the grid, then move towards to the light bulb, when being at the distance of maximum 4,5m it should reduce the brightness. Also when moving further than maximum 4,5m from lamp, it should increase the brightness again.

1.7 Project Planning

When project was chose then authors sat together, talked about their skills and knowledge. That gave better overview who is more familiar with each topic. At first, to get now and into this project, it was necessary to search current market and then divide tasks according to knowledge. Andra and Nils are studied marketing before, so they got marketing chapter. Piotr have some knowledge about Ethical and Deontological concerns. Norbert and David are both electrical engineers, they got technical tasks of project. You can find further information about our tasks in the following table (Table 1).

Table 1: Project planning

Task	Responsible
Proposal Research	Nils Petersen, Piotr Rzeznik, Andra Aedma, David González Alen, Ritter Norbert
State of art	Nils Petersen, Piotr Rzeznik, Andra Aedma, David González Alen, Ritter Norbert
Marketing plan	Nils Petersen, Andra Aedma
Introduction	Andra Aedma
Ethical and Deontological concerns	Piotr Rzeznik
Material planning	David González Alen, Ritter Norbert
Prototype	Nils Petersen, Piotr Rzeznik, Andra Aedma, David González Alen, Ritter Norbert
Project Developement	David González Alen, Ritter Norbert

Eco-eficency Measures for sustainability	Nils Petersen, Piotr Rzeznik, Andra Aedma
Video	Nils Petersen
Poster, leaflet	Nils Petersen, Piotr Rzeznik, Andra Aedma, David González Alen, Ritter Norbert
Conclusions	Nils Petersen, Piotr Rzeznik, Andra Aedma, David González Alen, Ritter Norbert
Final presentation	Nils Petersen, Piotr Rzeznik, Andra Aedma, David González Alen, Ritter Norbert

Further more, there is Ganttchart to give better visual overview of our activities:

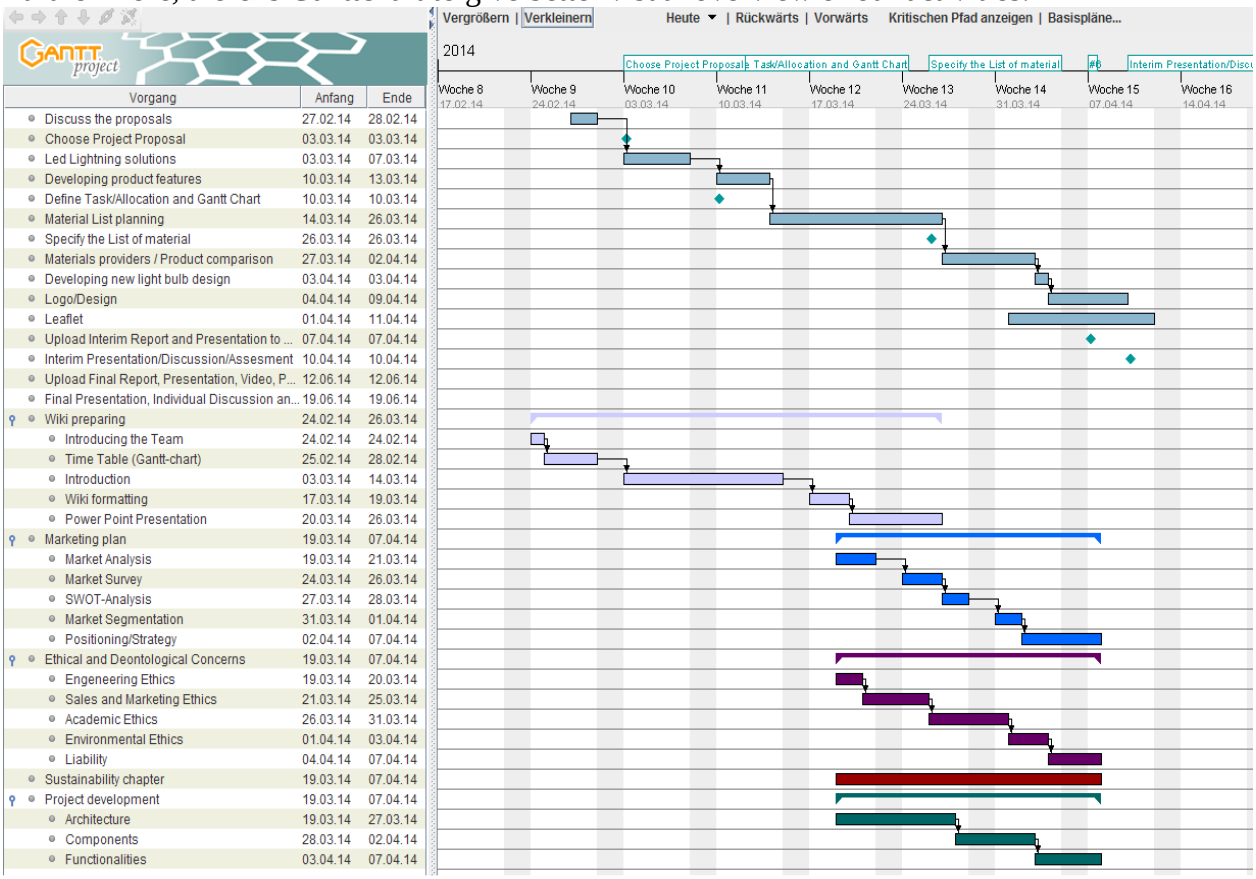


Figure 2: Ganttchart

1.8 Report Structure

This report is structured in seven different chapters.

The first chapter is the Introduction. This chapter consist of team presentation, problems what developed project have to face with, motivation, objectives, what results are expected and product planning.

In the second chapter, LED Lightning Solutions, is described different LED products and remote controls which are on the market right now, also authors have given a overview of our product technologies.

Chapter three - the Marketing plan, presents the Market analysis, positioning and segmentation, shows project weaknesses and strengths and also there is marketing mix, which is operational part of a marketing plan.

In the fourth chapter the Eco efficiency Measures for Sustainability is presented, highlighting the importance of sustainability in the engineering area and including a life-cycle and energy consumption analysis.

The fifth chapter describes the Ethical and Deontological concerns of our project.

The sixth chapter of the report concerns the Project development where the proposed solution of project is explained.

Lastly, in the conclusion chapter, the discussion about project is included as well as reference to possible further developments.

2. LED Lighting Solutions

2.1 Introduction

Firstly, there is described modular system and method for providing power for LED lighting systems to get know more about LED system details. The power source unit comprises a power supply that converts A/C voltage to regulated D/C voltage, a configurable intelligent gateway module that receives the regulated D/C voltage and places it on a power bus to which one or more power node modules and any accessories in need of power, such as motion detectors or cooling units, are coupled, and an intelligent power node module that converts the regulated D/C voltage to a regulated D/C current and provides it to the particular LED Light Module (LLM), and which also receives data from the LLM, such as temperature data, and adjusts the regulated current accordingly. The gateway module also may receive control data from control devices, such as dimmers or wireless controllers, and instruct the power node module to regulate its output current accordingly. [3]

In this chapter we are giving overview of application areas of LEDs (Table 2: Application areas of LEDs), introducing similar products to developed project, studying specifications of lighting system.

Table 2: Application areas of LEDs [3]

Application area	Application examples
LCD backlight	Mobile phones, cameras, portable media players (PMPs), notebooks, monitors, TVs
Transportation equipment lighting	Vehicle/train lighting, Ship/airplane lighting
General lighting	Indoor lighting, outdoor lighting, special lighting

2.2 Different LEDs [4][1]

Today's LEDs are available in many different types, shapes, and sizes. These advancements have led to better illumination, longer service life, and lower power consumption. They have also led to more difficult decision making, as there are simply too

[1] This paragraph is a shortened version of http://www.electronicproducts.com/Optoelectronics/LEDs/LED_101_Identifying_different_types_of_LEDs.aspx

many types of LED to choose from.

2.2.1 Miniature

Miniature LEDs are the most common form of LED available today (Figure 3). Miniature LEDs are considerably small, and usually available in a single shape/color. They're used as indicators on devices such as cell phones, calculators, and remote controls.

Given their unique size and simple design, miniature LEDs can be placed directly onto a circuit board, with no need for a heat-controlling/cooling device. As such, they are also used in sophisticated and technologically intense automated industries.

There are three subtypes of miniature LEDs: low-current, standard, and ultra-high-output, all of which vary in terms of current, voltage, and total wattage, depending upon the manufacturer. There are 5- and 12-V miniature LEDs available.

Figure 3: Miniature LED

2.2.2 High-power

Improved diode technology has resulted in this new category of LED, also referred to as a high-output LED as it offers a much higher lumen output than standard LEDs. Their high-power chips can emit light that registers several thousand lumens. Subtypes of high-power LEDs are typically characterized by a few parameters, including voltage, wavelength, and luminous intensity.

These lights pose the danger of overheating and so need to be mounted on an appropriate form of heat-absorbent material to allow the heat to cool via convection. This keeps them productive and effective, and helps the light avoid an early burn-out.

Always take heat control into consideration, no matter the type of high-power LED you are purchasing. Just as there are limits to maximum current, there are limits to certain

temperatures.

Typically high-power LEDs are findable in car headlights, high-powered lamps, and various mechanical, industrial, and scientific settings. Figure 4 shows how high- power LED looks like.

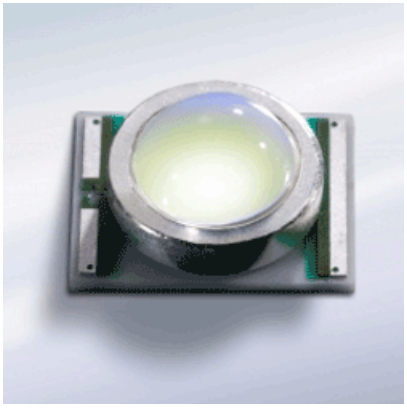


Figure 4: High-power LED

2.2.3 Application-specific LED lights

Typically, the flashing LED (Figure 5) is a standalone light that serves as a form of attention-seeking indication. It may look like a normal LED, but it contains an integrated circuit, in addition to the LED, which flashes the light at a specific frequency. Flashing LEDs are designed so as to be connected directly to a power supply with no series resistor required.

Figure 5: Flash

A bi-color LED light has two light-emitting dies in a single casing. It features three leads and is offered with either a common anode or common cathode. The wiring for the bi-color LED is considered “inverse parallel”; that is, one is forward and one is backward. This means that only one of the dies can be lit at a time. Current flow alternates between dies in order to produce color variation. If alternate the current at a high enough frequency, it will appear that both lights are on at the same time, and produce a third color. Appearance of bi-color and tri-color color LEDs can be seen in Figure 6.

Figure 6: Bi-color and Tri-color

Similar to a bi-color LED, the tri-color LED (Figure 7) also combines two light emitting dies in one encasing. What's different, though, is there are three leads instead. There is a center lead, which is the common cathode for both LEDs, and on either side are the outer leads, which are the anodes to the separate LEDs. This design allows for both dies to be lit either separately or together which, when the colors are combined, produce a third color. While this example describes a common cathode-based design, tri-color LEDs are available in either a common anode or common cathode configuration. RGB LEDs include red, green, and blue emitters, which allow for it to combine the three primary colors in different amounts to produce new colors with incredible precision. There are literally millions of possibilities of color combinations with today's increasingly sophisticated controllers.

Figure 7: Red, green, blue (RGB) LEDs

Most RGB LEDs use a 4-pin connection with a common lead, which is the longest connection (others have just two leads and include a built-in electronic control unit). Since the light requires electronic circuits to control the blending and diffusion of different controls, RGB LEDs offer users tremendous control of color emission. As a result, they're used a wide variety of applications, including light shows, video display, accent lighting, status indicators, and more.

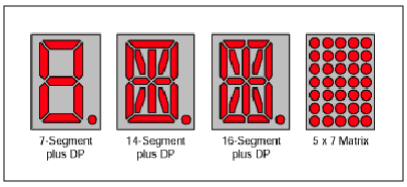


Figure 8: Alphanumeric

The alphanumeric LED light has fallen in popularity in recent years. While some point to the cancellation of the television show 24, the decline is actually due in large part to the increased sophistication of LCDs, which offer greater visual flexibility and much less power consumption.

As the Figure 8 show, there are four subtypes of the alphanumeric display. The 7-segment handles all numbers and only a limited set of letters; 14- and 16-segment displays are referred to as the "starburst" displays: they can cover the full 26-character Roman alphabet in upper case as well as numerals 0-9. Only difference between the two is a break on the top and bottom bars on the 16-segment digit.

Figure 9: Lighting LEDs

Lighting LEDs (also referred to as LED lamps, LED bars, or illuminators, picture in Figure 9) come in many different shapes and sizes, including the popular Edison light bulb design.

Heat dissipation methods vary based on manufacturer and how the light will be used. As new solutions are discovered though, this particular category of LEDs will continue to expand.

2.2.4 Advantages and disadvantages of LEDs

In this paragraph there are Tables 4 to 8 which are explaining LED Lamp advantages and disadvantages in different aspects.

Table 4: Advantages of LED Lamp [5]

Advantages of LED Lamp
Low heating generation to reduce electricity consumption
Saving money on energy bills
Greatly reduce carbon emission
Minimizing drastic climate change
Greatly reduce maintenance cost, long lifespan
Instant start, no flashing, solid state, shockproof
Save up to 90% power compared to ordinary bulbs
Long working hours, 24 hours per day is fine, produce very low heat
No mercury or other hazardous materials, accord with ROHS
Working environment - 20-40°C
No RF interference, No UV or IR Radiation

Table 5: Environmental benefits [5]

Environmental benefits
The LEDS comply with CE and ROHS regulations (“Restriction of Hazardous Substances ”) Restriction of Hazardous Substances Directive 2002/95/EC as
Not contain mercury or other heavy metals
Being more efficient, Led’ s produce less CO2 emissions to achieve the same illumination
Not generate as much heat as traditional lamps, with consequent savings in air conditioning
Low light pollution because the light emitted by the LED is always addressed, which is avoided in the case of village streetlights illuminate skywards
Its long duration means less need for raw materials for replacement lamps
No IR or UV radiation

Table 6: Economic benefits [5]

Economic benefits
Lower power consumption than the (fluorescent, incandescent, halogen, low power) ; with reductions ranging from 65% for fluorescent, to over 80 % for halogen and incandescent and

50% in low consumption
Depreciation quite fast within 3 years of the investment by the savings in lighting
High durability from 15.000h up to 50,000 hours , depending on the quality of the LED
Maintenance Light Flow on the original 70 % over its lifetime
Reduced cost of replacement and maintenance accordingly, and we saved the labor to replace it
Immediate start, disappear wasting time waiting for the lamp reaches the right temperature, or light up properly
Setting the backlight to our customer needs and wishes, both in quantity and intensity, there is a possibility to dim the led
Does not require replacement of existing lamp sockets, it is sufficient to perform simple rewiring
After installation does not require the protective cover, since most of the LEDs are made of aluminum and plastic, so that in case of breakage, any piece does not fall on food or people

Table 7: Benefits of design and architecture [5]

Benefits of design and architecture
Maximum design flexibility, there are LEDs of all sizes and with almost any design
Wide range of tones from 3000K to 7500K 's , not to mention the great game that gives the RGB
The boot is immediately obtained 100 % light output after power
Improving the efficiency of the system used to direct light
Unlike fluorescent lights, LEDs are more efficient in low temperature environments; LEDs have no starting problems in cold environments
They are reliable sources of light outside
Robustness and security against vibration
Light scattering outside which is desired is minimal due to the directionality of the LED
Regulation is total no color change
Ability to change colors in the same lamp
Plastic Optical high efficiency allowing more light can be used
Multiple possibilities for decoration

Table 8: Disadvantages of LED Lamp [5]

Disadvantages of LED Lamp
Greatest enemy is the high temperatures , from 65 most LED spoil
Not many LED lamps marketed substitutability of electronics
Require high thermal dissipation , but generate less heat than conventional , which dissipate heat generated is very important- is vital that the heat sinks are aluminium and very dissipation surface, so longer lamp life would be ensured
The price compared to conventional is quite high
In large powers from 100W , it is very competitive , having a very high cost , and there are alternatives such as magnetic induction
The large supply of these products makes it difficult to purchase choice , care must be taken with the selected suppliers, there is a huge intrusion in the sector
For lighting in the food sector , we have not yet managed to produce LED light for meat and fruit look more appetizing

2.3 Related products

There are a lot of similar products in the market. Table 9 brings out different kind of LED lighting solutions which are in the market right now.

Table 9: Related products

Product	Description	Features	Price [EUR]	Picture
TurnRound [6]	It is a basic range of fixed and adjustable LED down lights designed for accent, ambience and guidance lighting in retail and hospitality applications. It comprises dimmable warm-white and neutral-white versions, with a choice of narrow and medium beam	Available in fixed and adjustable versions; dimmable; 25 and 40° beam angles; high-Power LED technology	111	

	angles.			
iColor Flex MX [7]	iColor Flex MX is a multi-purpose, high-intensity strand of 50 full-color LED nodes for generating extraordinary effects without the constraints of fixture size or shape. iColor Flex MX enables patterns and video on almost any interior or exterior surface, including ceilings, floors, three-dimensional objects, sculptures, and more. Its small node size allows installation in tighter spaces than the larger iColor Flex SLX and iColor Flex LMX strands.	Strand consists of 50 individually addressable LED nodes; each node produces full-color light output of up to 1.44 candela. Flexible form factor. Works with complete Philips line of controllers, as well as third-party DMX controllers. Multiple lens options: clear dome and translucent dome lenses as standard; clear	352	

		flat and translucent flat lenses also available. Standard and custom lengths and node spacing.		
eW Flex SLX [8]	eW Flex SLX is a versatile strand of large, individually controllable white-light LED nodes. The durable, flexible form factor allows dynamic points of white light to be installed across nearly any interior or exterior surface, including walls, ceilings, floors, three-dimensional sculptures, and set pieces. eW Flex SLX can also light tight alcove spaces and signage.	Strand consists of 50 individually addressable LED nodes; each node produces full-color light output of up to 1.44 candela. Flexible form factor. Works with complete Philips line of controllers, as well as third-party DMX controllers. Multiple lens options: clear dome and translucent dome lenses as standard; clear flat and translucent flat	300	

		lenses also available. Standard and custom lengths and node spacing.[6]		
iColor Tile MX – LED light panel for stunning effects and large-scale video [9]	iColor Tile MX is a full-color LED light panel for creating stunning light art and accents in a variety of surface-mounted and recessed applications. Each panel has 144 individually addressable nodes to enable an infinite variety of effects at an unprecedented level of fine-grained control and intricacy. Install behind a custom panel, or use the available impact-resistant, translucent white diffuser lens for seamless, uniform optical effects.	Panel 597 x 597 mm; 144 individually addressable, high-intensity, full-color LED nodes, light output 599 nits. Designed for recessed and surface mounting on walls or ceilings. Quick set-up. Works with complete Philips line of controllers, as well as third-party DMX and Ethernet controllers.	133	
AmazonLED² [10]	When it comes to ground and wall-recessed markers, customers need an elegant yet discreet product that will last for years. AmazonLED² answers this	Available in warm white and blue; 230 V (class II) and 24 V (class III). Power supply	76	

	need. People will enjoy the soft light it gives off, as well as its modern, restrained appearance. Thanks to the high-quality stainless steel of the ring, the look of the luminaire will last over time, even in harsh environments.AmazonLED² is available in a choice of warm white and blue, and offers an easy retrofit in former AmazonLED fittings.	included for the 230 V version. Easy retrofit in former AmazonLED fittings.		
ArchiPoint iColor Powercore [11]	ArchiPoint iColor Powercore is a daylight-visible, exterior-rated LED point of light ideally suited for a range of direct-view and beacon applications, as well as for accent applications such as path and marker lighting. These versatile low-profile fixtures display large-scale video, graphics, and intricately designed dynamic effects in a host of settings, including architectural, retail, and entertainment installations. ArchiPoint iColor	Available in warm white and blue. 230 V (class II) and 24 V (class III). Power supply included for the 230 V version. Easy retrofit in former AmazonLED fittings.	475,2	

	Powercore offers high-intensity output with the efficiency and cost-effectiveness of Powercore technology in a rugged aluminum housing. Powercore delivers line voltage and data to fixtures over a single cable, dramatically simplifying installation and lowering total system cost.			
Marker LED [12]	Featuring SMD LEDs in combination with a diffusing glass cover, this luminaire is a clearly visible marker with a uniform light output. The Marker LED RGB version enables dynamic color changes, opening up a wide range of creative options and effects. The robustly designed Marker LED is available in round, rectangular and square versions and has an easy-to-install wall- and ground-recessed mounting box.	Compact fixture; uniform light output; enables dynamic color changes; available in round, rectangular and square versions, with an easy-to-install wall- or ground-recessed mounting box.	-	

LedUp light [13]	LED Uplight and LED Step deliver clearly visible markers with a uniform light output and enables dynamic color changing effects, opening up a wide range of creative options and design elements.	Activemix versions have the ability to create up to 16.67 million colors to offer endless color changing possibilities. 5 standard mono color versions: red, amber, green, blue, white. A die-cast aluminium housing offers a robust design and reliable operation over time. Can be installed in virtually any distance from the point of power supply without data degradation. Flexible installation via hassle-free connectivity.	-	

The LedStep rectangular BBS430 family [14]	Featuring high-powered LEDs, these rectangular-shaped luminaires are ideal for scene setting and enhancing landscapes and commercial environments. The mono color versions can create several clearly defined color bands. While its color-changing Activemix versions allow you to play with light, opening up a range of creative light patterns and dynamic effects	Activemix versions have the ability to create up to 16.67 million colors to offer endless color changing possibilities.5 standard mono color versions: red, amber, green, blue, white. A die-cast aluminium housing offers a robust design and reliable operation over time. Can be installed in virtually any distance from the point of power supply without data degradation. Flexible installation via hassle-free connectivity.	-	
The StraightLine family [15]	A city needs light, not luminaires. Architects, urban planners, municipalities… all need to	LEDGINE inside. Tiltable optic.	-	

	have the required lighting levels to ensure citizens' safety and well-being, but without cluttering the sidewalks and piazzas. The LEDGINE-based StraightLine provides them with a smart, efficient, future-proof solution which is in line with the street. This makes it less visible, thereby preserving the character of the local urban environment.			
MileWide LED [16]	Milewide is a pure, contemporary street-lighting luminaire designed in collaboration with Knud Holscher (Denmark). A complete solution with dedicated masts and brackets is available to ensure perfect integration in today's cityscape. Blending clean, simple design and high performance, the Milewide family encompasses three sizes: Mini Milewide, Milewide and Mega Milewide. Mini Milewide has been specially designed around CosmoPolis technology,	Clean, Nordic design. LEDGINE module. Dedicated masts.	-	

	thereby pushing the limits in terms of minimization and performance. This has been taken a further step forward with the incorporation of the latest LED technology. Milewide and Mega Milewide deliver high optical performance thanks to the adjustable road-lighting reflector and have been optimized for different street configurations.			
CitySpirit [17]	CitySpirit Street is part of the CitySpirit gen2 range, a hybrid range designed to provide excellent, environmentally friendly lighting without compromising on architectural appearance. The range consists of indirect lighting solutions, such as the Cone, Torch, Modern Lantern, Classic Lantern, Wall-mounted and Bollards and a direct lighting solution, namely CitySpirit Street and CItySpirit Street LED. CitySpirit Street LED incorporates our LEDGINE	Choice of conventional or LED light sources (upgradeable LED light engine). Variety of optics addressing maximum spacing and visual comfort. The LED version is also available with a transparent ring that can be colored by LED's in blue or	-	

	module, providing a long-lasting solution that can be upgraded simply by replacing the module. This enables significant energy savings through 1-to-1 replacement of HID installations without any compromise on lighting quality or safety. Together with its constant light output and dimming functionality, the LED version ensures the highest operational efficiency.	white.		
The SecuriPack [18]	Everyone wants to feel safe after dark, and yet we're also conscious of the need to save energy. The solution to this dilemma is here in the form of SecuriPack, a ceiling- or wall-mounted security and amenity lighting luminaire. LED-based, it delivers low-energy lighting all night long. Its translucent bowl provides excellent light distribution for low-level lighting of walls, corridors and surroundings. The high reliability and longevity of LEDs means that neither	Continuous energy-efficient lighting. Reliable long-lasting LEDs. Sturdy, vandal-resistant design and construction.	-	

	lamp replacement nor maintenance is required during the luminaire's long service life, thus reducing costs. SecuriPack's robust, vandal-resistant construction makes it suitable for both outdoor and indoor applications.			
The Stela Long, Square & Wide family [19]	Stela is at the forefront of LED technology in street lighting. REVOLED cooling and light distribution concept enables enormous energy savings and CO2 reductions, whilst meeting current lighting standards. Excellent thermal management of the LEDs ensures a very long lifetime, eliminating the need for lamp replacement and resulting in a very attractive Total Cost of Ownership. Stela has its own clear own identity, which heralds a new era in lighting.	Guaranteed long lifetime ~ 100,000 hours at 350 mA.Low Total Cost of Ownership. Low energy consumption and carbon footprint. Easy installation and maintenance.	-	
The DayZone family [20]	For general office lighting, customers want to capture the benefits LED technology has to offer – sustainability and fresh,	Lumen package enabling 500 lux using conventional luminaire	-	

	high-impact design, without compromising visual comfort. Our DayZone recessed LED luminaire delivers high-quality functional lighting with an energy efficiency that matches or even outperforms traditional fluorescent systems. But what makes DayZone really shine is its impressive visual comfort. Our innovative use of LED technology has created a luminaire that breaks away from fluorescent lighting designs of the past to offer a striking appearance and light effect. Glare control and color consistency are compliant with future office norms. DayZone is available in square versions and, to ensure a better fit in plaster ceiling applications, in a round housing.	spacing. Dedicated MLO optic design. Special patented light-mixing chamber. Round housing available for plaster ceiling applications.		
GentleSpace [21]	Customers in industrial and warehousing applications are constantly looking for ways to reduce the amount of energy required to light their facilities. GentleSpace	Available in two sizes: four and two pods of LEDs respectively, replacing 400 W	-	

	is the first LED high-bay luminaire that can directly replace HID high-bays of up to 400 W, enabling significant energy savings. LEDs also provide instant light and the possibility to dim the light level. And GentleSpace is DALI-dimmable, so even more energy can be saved. The luminaire comes in two sizes and offers a choice of dedicated high-quality optics, which fill the space with a gentle, comfortable light. All versions include steady Gripple Y-fit hangers that can carry up to 45 kg for easy and secure installation. GentleSpace is also equipped with a high-quality, thermally toughened, extra-white glass cover for high translucence. Its flat design saves space at the top of the building, leaving room for e.g. sprinkler installations	and 250 W metal-halide high-bay solutions LED Gine platform, instant light and long lifetime. Choice of medium-beam, wide-beam and high-rack optics. Gripple Y-fit hangers for easy and secure installation; extra-white glass cover Optional integrated movement detectors for extra energy saving.		
HDE® Remote Control Color Changing 16 LED Light Bulb	Liven up any room or outdoor light with this remote controlled LED light bulb. This light bulb	Operates in standard light sockets.5 watt 16 color LED;	7,2	

with RC [22]	has 16 colors and four different settings controlled by a remote. Settings include: flash, strobe, fade, and smooth. The 5 watt LED is bright and fun. The light bulb fits in standard light sockets.	color: red, green, blue and white; adjustable shades and brightness; batteries: CR2025 included; size: 2.5” / 6.35cm; package contents: 1 x LED Light Bulb; 1 x remote.		
LivingColors Bloom White [23]	Philips LivingColors Bloom LED lamp. Expressive and different. Placed in the back or front row, smoothly blends in your interior. Just take the remote control, select one of the 16 million colors and enjoy the mood lighting.	Choose among 16.000.000 colors, dimmable, light output 120 lumen, easy-to-use remote control, adjustable color intensity, automatic color changing mode, nice diffused light effect, 2 buttons to store your favorite colors.	72	
Camera led flash module [24]	Super bright top grade 3528/5050 SMD LED light source3528SMD, single-lumen 5-6LM, 5050SMD	Beam angle: 120-160 degree. Energy efficient, major reduction	0,5	

	single-lumen 18-20LM twenty pcs modules as a string/group.	in power costs. Low heat, high brightness, works well under harsh conditions. Full range of colors: Red, Yellow, Blue, Green, White, Warm White. Solid-State and high shock/vibration resistant.		
LED Lenser P5.2 - 140 Lumen [25]	The LED Lenser P5.2 is a small, slim line LED hand torch which deserves five stars for stylish design, outstanding performance and superb technology. With a durable aircraft grade aluminium body, matt black easy-grip finish that is also more abrasion resistant, distinctive contrasting red trim and one-hand sliding Speed Focus™, this is a torch that feels as good as it looks.	Type: professional hand-held torchOperating; Modes: 140 lumensBeam; range: 120; mRun time: 5 hours (down to 1 lumen); maximum luminous flux: 140; lumensLED: CREE; LED chipFocus: one handed speed; focus optics: advanced focus	36,15	

		system. Overall Length: 113 mm; Head Diameter: 26 mm; Barrel Diameter: 18.5 mm; Weight: 79 grams; Material: aircraft grade aluminium		
LEMONBEST 16.4FT SMD 5050 Water-resistant 300LEDs RGB Flexible LED Strip Light Lamp Kit + 44 Key IR Remote Controller [26]	Widely used for home decoration, hotels, clubs, shopping malls. Architectural decorative lighting, boutique atmosphere lighting. Extensively applied in Back Lighting, concealed lighting, channel letter lighting. Decorative lights for holiday, event, show exhibition.	LED type: SMD 5050; Length: 16.4FT (5M); LED Quantity: 300LEDs / 16.4FT; Color: RGB; Beam angle: 120 degrees; Input voltage: 12V DC; Working Temperature: -20°to 50°; Size: L16.4ft * W 0.40inch * T 0.10 inch; Protection Rate: IP65; Waterproof; Can be cut 3 LEDs per Unit.[24]	12,3	

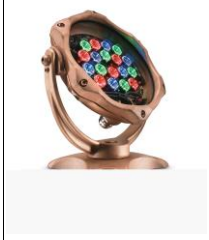
Romantic Bright Automatic 7 Color LED Shower Head Facut Home Bathroom Water Glow [27]	Beautiful & Romantic 7-Color LED Showerhead. Mixing light and water , bring a dreamlike world. Offer you a delight bath & a wonderful experience. The shower handle connects directly into your shower pipe. Brightness is such enough even no other lighting fixtures need. Transforming the stream of water into a beautiful waterfall of light. Low flow, water conservation with a unique fun and soothing experience. The change of LED color will not be subject to the temperature of water. Seven colors are displayed circularly and gradually when the water runs through.	Color: Silver; Net Weight: 146g; Case Material: ABS Showerhead; Diameter: 83mm; Surface treatment: Electroplating; Dimension: Approx.83(W) x 90(L)cm; Connector Size: 20mm female thread; LED Emitting Color:7 colors gradually changed.	7,4	
The eW Profile Powercore [28]	eW Profile Powercore is a direct line voltage, under-cabinet LED fixture for common task lighting and display case applications. Available in 3000 K or 4000 K color temperatures, eW Profile Powercore is suitable for new	Choice of neutral (4000 K) or warm (3000 K) white light. Light output of over 1000 lumens per meter 20º offset beam angle for uniform light	111	

	installations and retrofits requiring superior illumination quality and dramatic energy savings.	quality for the products on display. Available in white, gray and black housing colors. Integrated Powercore technology.		
The ColorFuse Powercore [29]	With narrow beams of high-quality color-changing light, ColorFuse Powercore is an excellent choice for a full range of surface grazing, wall-washing, and accent lighting applications. Its ultra-compact form factor permits installation in tight spaces too small to accommodate conventional grazing fixtures that offer a similar level and distribution of light.	Advanced color mixing and superior color consistency. Light output of 380 lumens per fixture. Rotation in 10º increments through full 180º for precise aiming and color mixing.	214	
The DecoScene LED [30]	DecoScene is a ground-recessed uplighter for enhancing, highlighting or even revealing the architecture of the city at night. An unobtrusive presence by day, DecoScene offers a wide choice of light sources, beams, adjustment	Choice of conventional and LED versions. Wide choice of light colors, adjustment possibilities and accessories Complies with CEI 60598-2-13	377	

	possibilities and accessories to deliver the optimum upward lighting effect after dark, e.g. to illuminate monuments, highlight a striking piece of architecture or mark out a luminous path through a park or garden.	norm.		
The ColorBurst [31]	It combines the classical look of a round spotlight with all the benefits of intelligent LED technology. Enclosed in a rugged, die-cast aluminum housing, this compact spotlighting and wall-washing fixture projects rich, saturated colors and color-changing effects, both indoors and outdoors.	Light output of over 500 lumens while consuming just 25 W at full intensity. Choice of 10° clear lens for extended light projection and 21° frosted tempered glass lens for a soft-edge beam. 350° locking base swivel and 350˚ locking fixture rotation.	309	
ColorBlast Powercore [32]	It combines rich, saturated, wall-washing color and color-changing effects with simplified installation. ColorBlast Powercore offers a single solution for both indoor and outdoor applications, while a range	Medium beam angle 36º. Color: white, dimmable.	431	

	of beam angles make the fixture ideal for washing, grazing, floodlighting, and spot lighting.			
The ColorReach Powercore [33]	ColorReach Powercore is the first LED fixture powerful enough to brilliantly and dynamically illuminate large architectural façades. ColorReach Powercore combines all the benefits of LED-based lighting and control in an elegant fixture specifically designed for large-scale installations, such as commercial skyscrapers, casinos, large retail exteriors, bridges, piers, public monuments, and themed attractions.	Rich, saturated color light output of over 8,000 lumens and light projection over 150 meters; Exchangeable spread lenses of 8°, 13°, 23°, 40°, 63°, and an asymmetric 5° x 17° ; Simple positioning and fixture rotation through full 360°.	-	
The eW Graze MX [34]	Property owners/end users need a controllable product capable of dynamic illumination to draw attention to their establishments and emphasize their brands. Graze MX Powercore is capable of illuminating over 20 meters at very close setback distances.	Highest-intensity exterior-rated linear LED luminaire in the market. High output and beam quality thanks to holographic diffusion technology. Unparalleled control via	180	

		adjustable dimming curves and transition speeds.		
The LEDline² [35]	LEDline² is a high-performance linear grazing light creating color-changing effects and seamless curtains of light. Available in a wide range of colors, optics and forms the linearity of LEDline² complements the geometry of the architecture transforming light into objects.	High-performance linear grazing light to create color-changing effects and seamless 'curtains' of light. New white color variations from cool to warm white are ideal for enhancing buildings, facades and architectural details. Linear forms complement geometry of the architecture and transform light into objects.	-	
The Maxos LED [36]	Maxos LED Recessed is a semi-modular recessed LED luminaire for shelf and gondola lighting. Thanks to its adjustable optic, the light can be	Highly efficient LED light engine. Advanced optical system. System	378	

	aimed precisely at the products on the shelves or at signage. The dedicated beam shape results in maximum visibility of the merchandise on display and less spill light.	efficiency above 79 lm/W. 50,000 hours lifetime. Plug-and-play electrical connection.		
The C-Splash 2 [37]	C-Splash 2 is an ultra-thin, submersible fixture designed to provide vibrant color and color-changing light in fresh and saltwater locations to a depth of 4.6 meters. With its watertight cast brass housing and silicon bronze adjusting hardware, C-Splash 2 is perfect for water-based applications such as fountains and theme park installations, as well as for applications situated in harsh environments.	Long-life LEDs delivering RGB colors and light output of over 500 lumens. IP68-rated: also able to withstand water treated with bromine or chlorine. 10° clear glass lens for extended light projection and 22° frosted tempered glass lens for a soft-edge beam.	924	
X3B Freezer Light [38]	Energy Saving, Long Lifespan CCT adjustable; Patent design: small diameter only 19mm,selection aluminium construction, consise and genrous, exquisite and beautiful. Emitting different CCT light according to	Application: Goods Shelf, Store Refrigerator, Department Counter, Jewelry Counter.	-	

	customer requirements, can make a more better display effects for goods. Prolongable connection, suitable for general adapter. Round section, light directing can be adjusted, installing freely.			
X5 Freezer Light [39]	Freezer inner illumination, refrigerator inner illumination, bakery and confectionery, pharmaceutical factory, fishery industry, edible mushrooms industry(suitable for various sites where require water-proof explosion-proof and not easy to replace, is the revolutionary replacement for traditional “tri-proof”, “explosion-proof”)	3/4 alumninium construction, small diameter but good heat dissipation, light source and driver being gumming, IP grade reaches to IP65. Ingenious design of two ends: prolongable connection, universal usage with the common product connector. Connector with protection function, IP65,unique in domestic, first creation around the world. Patented	10	

		protection construction, without unnecessary parts, concise and generous, 360°adjustable, easy installation.		
Lumos LED shelf luminaries [40]	Lumos LED head luminaire for mounting behind the roller blind of the housing of open cold stores; LED with 4000K color temperature; two light distribution patterns in one luminaire: extremely narrow distribution along the front of the shelving and diffuse distribution for the upper shelf surface.	Light color 4000K; for color-true light across complete color spectrum.	-	
LED A Shape [41]	Philips A19 LED light bulbs deliver exceptionally long life, significant energy savings, beautiful light and contain no mercury. This 11 watt can replace a standard 60 watt incandescent and can save in energy costs.	Provides light similar to natural daylight, lasts 22.8 years, instant on, reduces energy costs, similar shape and size as standard incandescent, dimmable.	17	

Reflector - Flood [42]	Philips PAR38 LED light bulbs deliver exceptionally long life, significant energy savings, beautiful light and contain no mercury. This 13W can replace a standard 75W halogen and can save in energy costs.	Provides Bright Crisp Light, lasts 22.8 years, instant on, reduces energy costs, similar shape and size as standard incandescent, dimmable.	17	

2.4 Remote controls

The most common remote control types are WIFI, Bluetooth and IR (Figure 10), there is also available remote control through radio waves, but this option is not very widely used.

Figure 10: Logos [43]

2.4.1 WIFI

Wi-Fi, is a popular technology that allows an electronic device to exchange data or connect to the internet wirelessly using UHF radio waves. Wi-Fi Remote Control is a simple application to control devices via local Wi-Fi network. You need to know IP address, port, command code to setup your device into menu. It is controllable for example your smart Wi-Fi/Ethernet TV, IP Camera, Arduino+ Ethernet card and other new Wi-Fi, Ethernet devices. [44]; [45]

For this type of controller needs to have a smartphone or tablet. It is necessary to download App for Android or IOS. There are many different applications to control LED light bulb.

Table 10: Specifications of Wi-Fi box [46]

SPECIFICATIONS OF WI-FI BOX	
Power supply	Adapter or USB DC5V 500 mA
Wi-Fi connectivity	Direct or via home network
Wi-Fi security	WPA WPA2
RF transmitter	8 zones 2.4 GHz

In the following picture is shown Wi-Fi interface (Figure 11).

Figure 11: WI-FI Interface [46]

Table 11: Specifications of remote [47]

SPECIFICATIONS OF REMOTE	
Controls	4 Zone touch screen
Functions	on/off, dimming, color selection, program selection, effect mode speed
Distance	20 meters through walls
Batteries	2 x AAA penlite 1,5 Volt
Dimensions	110 x 52 x 20 mm
Frequency	RF 2.4 GHz

2.4.2 Bluetooth

Bluetooth is a wireless technology standard for exchanging data over short distances using short-wavelength UHF radio waves in the ISM band from fixed and mobile devices, and building personal area networks. Bluetooth operates in the range of 2400–2483.5 MHz. This is in the globally unlicensed. Industrial, Scientific and Medical (ISM) use 2.4 GHz short-range radio frequency band. Bluetooth uses a radio technology called

frequency-hopping spread spectrum. The transmitted data are divided into packets and each packet is transmitted on one of the 79 designated Bluetooth channels. Each channel has a bandwidth of 1 MHz. Bluetooth 4.0 uses 2 MHz spacing which allows for 40 channels. The first channel starts at 2402 MHz and continues up to 2480 MHz in 1 MHz steps. It usually performs 1600 hops per second, with Adaptive Frequency-Hopping (AFH) enabled. A master Bluetooth device can communicate with a maximum of seven devices in a piconet (an ad-hoc computer network using Bluetooth technology), though not all devices reach this maximum. The devices can switch roles (for example, a headset initiating a connection to a phone will necessarily begin as master, as initiator of the connection; but may subsequently prefer to be slave).[44] Every product doesn't work with android or IOS, so this project requires different controller system. Bluetooth 4.0 only works with IOS. Below there is picture of Bluetooth interface (Figure 12) and also table of Bluetooth properties (Table 12). [48]

Figure 12: Bluetooth Interface [49]

Table 12: Bluetooth properties [49]

PROPERTIES
Up to 24 V and 2 A per channel
5 Channels (Red, Green, Blue, Warm, White, Cold White)
Low Stand-By Consumption
Up to date Bluetooth 4.0 Chip
Easily accessible Terminal for connecting LED stripes
Temperature resistant from 0°C to 50°C
Automated shutdown on overheating
Suitable for DIN rail mounting

Easy integration of up to 5 controllers into one network
Free iPhone App

2.4.3 IR (Infrared)

The signal between a remote control handset and the device it controls consists of pulses of infrared light, which is invisible to the human eye, but can be seen through a digital camera, video camera or a phone camera. The transmitter in the remote control handset sends out a stream of pulses of infrared light when the user presses a button on the handset. A transmitter is often a light emitting diode (LED) which is built into the pointing end of the remote control handset. The infrared light pulses form a pattern unique to that button. The receiver in the device recognizes the pattern and causes the device to respond accordingly. In following there are pictures about IR remote controls in Figure 13. [50]

Figure 13: IR interface and Remote controller [51]

Table 13: IR Specification [51]

Working temperature	-20^{0}C +60^{0}C
Size	63mm x 35 mm x 22 mm
Weight	0.25 gr
Output	<2 A max 6 A
Supply Voltage	12 V
IR controller Battery	CR2032
Connection type	Common anode
Model	LE-LL19111
Maximum distance for use	10 m

Wiring diagram of Infrared remote control is presented in the Figure 14.

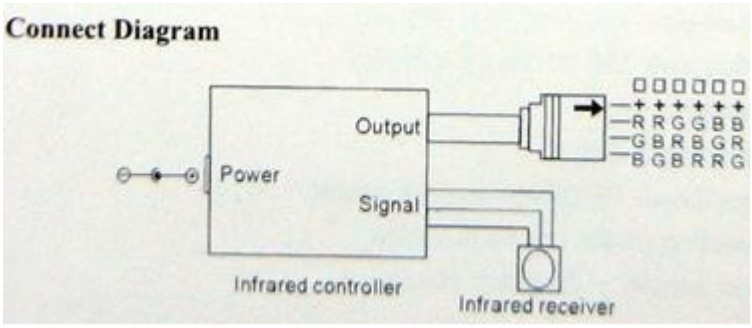


Figure 14: Wiring Diagram [52]

Table 14: Remote control layout [52]

REMOTE CONTROL BUTTON LAYOUT			
Brightness + (7 steps)	Brightness - (7 steps)	Off	On
Static red	Static green	Static blue	Static white
Static orange	Static pea green	Static blue	Static white
Static dark yellow	Static cyan	Static magenta	All fade out & fade in
Static yellow	Static light blue	Static pink	7 colors fade
Static light yellow	Static sky blue	Static purple	3 colors smooth transition

This IR remote controller and LED control unit is specially designed to work with 12 VDC. It is possible to create custom lighting effects with 24 buttons. Adjust brightness, color, fade in/out and flash rate.

Applications for color changing light bulbs: homes and restaurant lighting, clubs, bars, studios, landscape scene/spot lighting, architectural lighting, merchandising, displays and exhibition stands, artwork lighting, at theatres and entertainment venues.

2.4.4 Advantages and disadvantages of remote controls

Everything has a two sides, disadvantages and advantages. In Table 15 are showed different kind a remote controls positive and negative sides.

Table 15: Advantages and disadvantages of remote controls

REMOTE CONTROLLERS		
Type of controller	**Advantages**	**Disadvantages**
IR	▪ Easy function. ▪ Cheap. ▪ Simplicity. ▪ Easy for buy a new controller.	▪ Distance to use only 10 m. ▪ Can't create scenes.
WIFI	▪ You can controller 5 lamps. ▪ 20 meters through walls	▪ Needs all time your smartphone. ▪ Not working WI-FI. ▪ Needs router.
Bluetooth	▪ Control of multiple lights. ▪ Automatically switches the light on/off to deter intruders.	▪ Needs iOS don't run with Android. ▪ You need have open the App always.

2.5 Brightness control

For brightness control authors were considering using ultrasonic sensor or laser sensor. In the following there are descriptions of these sensors and also comparison between them.

2.5.1 Ultrasonic sensor

Ultrasonic sensors (Figure 15) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. This technology can be used for measuring wind speed and direction (anemometer), tank or channel level, and speed through air or water. [53]

Transducers

Systems typically use a transducer which generates sound waves in the ultrasonic range, above 18,000 hertz, by turning electrical energy into sound, then upon receiving the echo turn the sound waves into electrical energy which can be measured and displayed. An ultrasonic transducer is a device that converts energy into ultrasound, or sound waves above the normal range of human hearing. While technically a dog whistle is an ultrasonic

transducer that converts mechanical energy in the form of air pressure into ultrasonic sound waves, the term is more apt to be used to refer to piezoelectric transducers or capacitive transducers that convert electrical energy into sound. Piezoelectric crystals have the property of changing size when a voltage is applied, thus applying an alternating current (AC) across them causes them to oscillate at very high frequencies, thus producing very high frequency sound waves. The location at which a transducer focuses the sound can be determined by the active transducer area and shape, the ultrasound frequency, and the sound velocity of the propagation medium. [53]

Use in industry

Ultrasonic sensors are used to detect movement of targets and to measure the distance to targets in many automated factories and process plants. Sensors with an on or off digital output are available for detecting the movement of objects, and sensors with an analog output which varies proportionally to the sensor to target separation distance are commercially available. [53]

Figure 15: Ultrasonic sensor [53]

2.5.2 Laser sensor

Laser sensors are used where small objects or precise positions are to be detected. They are designed as through-beam sensors, retro-reflective sensors or diffuse reflection sensors.

Laser light consists of light waves of the same wave length with a fixed phase ratio (coherence). This results in an important feature of laser systems, that is the almost parallel light beam. The result: Long ranges can be achieved thanks to the small angle of divergence. The laser spot which is also clearly visible in daylight simplifies the alignment of the system. [54]

Distance sensors

Sensors for distance measurement (Figure 16) operate according to the time-of-flight principle. A light beam is emitted and reflected by an object. The time the light beam takes for the distance from the unit to the object and back from the object to the unit is measured. Since the speed of light is constant, the distance can be calculated on the basis of the time of flight. [54]

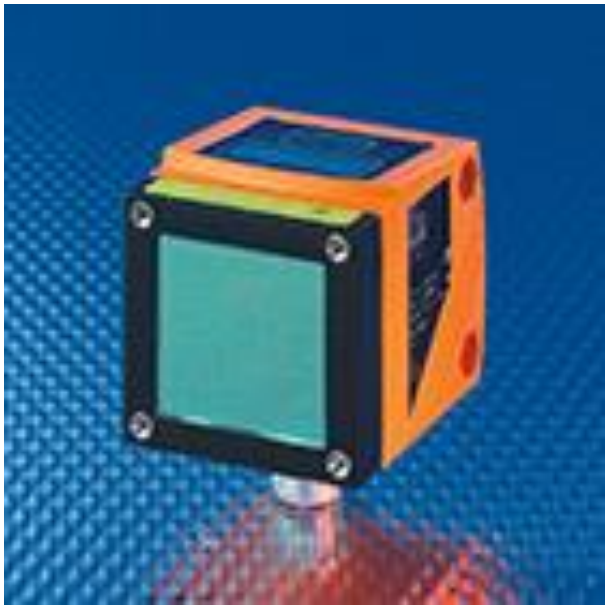


Figure 16: Distance sensor [54]

2.5.3 Comparison

In order to compare different options of brightness control sensors, there is a Table 16 which explains both sensors positive and negative sides.

Table 16: Comparison of Ultrasonic and Laser sensor

Product	Advantages	Disadvantages
Ultrasonic sensor	An ultrasonic sensor's response is not dependent upon the surface color or optical reflectivity of the object; ultrasonic sensors with digital (ON/OFF) outputs have excellent repeat sensing	Ultrasonic sensors must view a surface (especially a hard, flat surface) squarely (perpendicularly) to receive ample sound echo; while ultrasonic exhibit good immunity to background noise,

	accuracy, it is possible to ignore immediate background objects, even at long sensing distances because switching hysteresis is relatively low; the response of analog ultrasonic sensors is linear with distance, by interfacing the sensor to an LED display, it is possible to have a visual indication of target distance - this makes ultrasonic sensors ideal for level monitoring or linear motion monitoring applications; cheap (0,96 €); small	these sensors are still likely to falsely respond to some loud noises, like the "hissing" sound produced by air hoses and relief valves; ultrasonic sensors have a minimum sensing distance; changes in the environment, such as temperature, pressure, humidity, air turbulence, and airborne particles affect ultrasonic response
Laser sensor	Distance measure at light speed (depends on the processor speed also); ideal for near real time positioning of an object	Depends on weather; visual path should be clear; dusty air, rainy or cloudy day will effect the accuracy or even unusable; expensive (100€); big

2.6 Conclusion

There are many different LED Lamps with different range of application in the market right now. For example LEDs are used in supermarket refrigerators, for disco club illumination, in toys, mobile devices, intelligent houses, for garden illumination, road lighting, in regular household and so on. Our idea is to create Modular LED Lamp, which fits to universal lamp socket, user can change colors by using remote control, lamp has intelligent automatic brightness control system, dynamical dimming system and LED Lamp has easy construction to change the Led. There are many color changing lamp offers, but automatic brightness control system is not common for lamps, so it Modular LED Lamp is innovative with this feature. In the following there is final decision about materials which is findable in Table 17. Closer look of our ideas, strengths and weaknesses you can find on the following chapter, called marketing.

Table 17: Materials advantages

PRODUCT ADVANTAGES	
Pic controller	▪ Small ▪ Cheap ▪ We can do the programing in Pic ▪ It is available in 8 bit version
IR	▪ Small ▪ This is the most common used IR ▪ It's very reliable ▪ Cheaper than Wi-Fi or Bluetooth; ▪ Small space requirement on the PCB ▪ It only requires an IR receiver ▪ It doesn't requires separate module ▪ For the Bluetooth or Wi-Fi module we would have to buy a bigger microcontroller which is more expensive
FETs **Jumpers** **Connectors**	▪ Low drain resistance because of the PWM (Pulse-width modulation) the switch speed matters. This one has low rise/fall time ▪ If the module freeze we have a safety option to restart it manually ▪ Reliable ▪ No corrosion
Switch	▪ Simple press button, normally open state
Transistors **LEDs/sensor**	▪ We need the power output to drive the IR ▪ We will put 4 RGB LEDs on a different panel and connect it to the led driver, if a led stops to work we can only change the led
Ultrasonic sensor	▪ Simple ▪ Has SPI output ▪ Very accurate for this price ▪ Simpler and cheaper than a laser sensor

3. Marketing Plan

3.1 Introduction

So far lighting has been considered largely a functional issue. End consumers have questioned whether the quality, type and location of lights were conducive to worker productivity, an attractive home or office environment and perhaps even a personal or corporate image. At the same time, producers viewed the lighting industry as a mature industrial market. Keys to success were lowering manufacturing costs through large-scale production and low cost capital and labor inputs, while maintaining a strong position in relevant distribution channels. Less attention was paid to innovation and development. Nowadays customers, large-scale producers and startups are increasingly aware that lighting is as much an energy issue as it is a matter of functionality. Lighting in all segments (residential, commercial, industrial, and outdoor) consumes almost 20% of the energy in the built environment, internationally. The market for light emitting diodes (LEDs) has a high potential in the global general lighting market. Light management systems and color control of LED light, which can affect the mood of the end users enabling a purpose-friendly ambience, will shape the market into a new sphere.

We are entering to the LED lighting market, for which ResearchMoz is predicting in it´s market research report "Global LED Lighting Market 2012-2016" 35.6 percent growth over the period 2012-2016. One of the key factors contributing to this market growth is the declining average selling price of LEDs. The Global LED Lighting market has also been witnessing an increasing adoption of LEDs. The worldwide high-brightness LED market surpassed $14 billion in 2013, with 10 companies accounting for more than 68% of the market. Lighting, which doubled revenues since 2012, now accounts for 30% of the market. [55]; [56]

According to the prediction of LED increasing market, we have good prospects to enter to the market. Our product is Modular LED Lamp, which has several features:

- Fits to universal lamp socket;
- Change colors with remote control (radius 10m);
- Easy construction to change the Led;
- Include an automatic brightness control system (maximum radius 4,5m)

We are aware that we have many competitors who are offering LED lighting (day lighting, mood lighting), but we offer among other features automatical brightness control system, which is not so common in current market products. Our product is concentrated more to mood lightning market.

Following chapter discuss about our product market size, possible market increase or decrease. Also identify our strengths and weaknesses, identify competitors and target market. There is description about our strategies and price.

3.2 Market Analysis

3.2.1 Macro Environment

A Macro Environment Analysis is a review of factors that a company is unable to control. Companies may conduct this to stay ahead of the issue in the current business world. A common tool for this is the PESTEL framework, but in this analysis we use PESTO tool, which includes factors from political, economical, social, technological and other (legal, ecological) environments. We evaluate the level of dependency of our business area to each PESTO environment.

Political environment:

Nowadays green politics is a rising trend. Green politics is a political ideology which is trying to create an ecologically sustainable society rooted in environmentalism, social justice, and grassroots democracy. By now Green parties have developed and established themselves in many countries across the world and have achieved some electoral success. [57]

European Union promotes environmental friendliness as well, for example European Commission is worried about energy efficiency. On 8 March 2011, the European Commission adopted the Communication “Energy Efficiency Plan 2011” for saving more energy through concrete measures. The set of measures proposed aims at creating substantial benefits for households, businesses and public authorities: it should transform daily lives and generate financial savings of up to 1000€ per household every year. It should improve the European Union´s industrial competitiveness with a potential for the creation of up to 2 million jobs. [58]

Energy efficiency is not a issue for only Europe, but it concerns organizations worldwide.

Canadian Industry Program for Energy Conservation and Natural Resources Canada can help your organization cut costs, improve energy efficiency and reduce industrial greenhouse gases. [59] Latin America and the Caribbean, energy efficiency may offer the greatest impact at the lowest cost of all the untapped sources of clean energy. Inter-American Development Bank researchers have estimated that the region could reduce its energy consumption by 10 percent over the next decade and save tens of billions of dollars by adopting existing technologies to increase efficiency. [60] China had plan for medium-and-long-term energy conservation for the 11th five-year period (2006-10)where country set its focus of energy saving in the industrial sector, transportation and construction industries, as well as commercial and civil power use. [61]

Connecting our work with this subject, we provide energy efficient lighting. LED lamps are todays most efficient way of illumination and lighting, with an estimated energy efficiency of 80%-90% when compared to traditional lighting and conventional light bulbs. This means that about 80% of the electrical energy is converted to light, while a ca. 20% is lost and converted into other forms of energy such as heat. [62]

Economical environment:

Macroeconomic influences are broad economic factors that either directly or indirectly affect the entire economy and all of its participants, including our business. These factors include such things as interest rates, taxes, inflation, currency exchange rates, consumer discretionary income, savings rates, consumer confidence levels, unemployment rate, recession. For example if company is established, it is necessary to pay property tax, excise taxes (paid by a business for certain types of consumption and activities), business income taxes, sales tax, self-employment tax (paid by sole proprietors and partners for social security and medical care, based on the income of the business), employment taxes/ payroll taxes (these taxes include social security/medical care, federal/state unemployment, and federal/state worker's compensation taxes). [63]

Coming back to LED lighting, then the LED lighting market is anticipated to grow 45 percent per year through 2019. The LED lighting market at 4.8 billion dollar in 2012 is anticipated to go to 42 billion dollar by 2019. The reason of the growing market is the declining price, the increased interest by the channel in pushing LEDs to consumers. In that moment LEDs are the best lighting solution. The phase out of incandescent lights has begun, the onset of LED command of the market is upon us. Figure 17 shows LED lighting

expansion in recent years. [64]

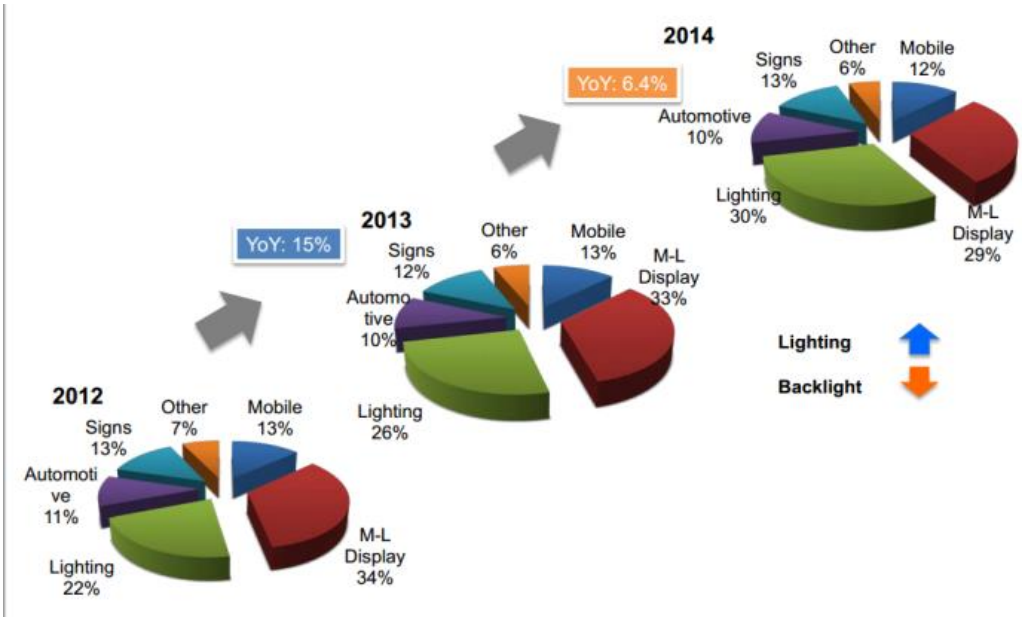


Figure 17: LED lighting expansion [64]

Social environment:

"Green thinking" is getting more and more popular among people. More people are becoming accepting of the reality of climate change, the impact humans are having on the planet and realization that something needs to be done to improve our natural environment. Nowadays recycling is a common action, people buy more second hand clothes, they use hybrid and electric cars instead of diesel or gasoline, also renewable energy usage have improved. People are started to think how to save money by using sustainable energy.

Technological environment:

It is 21st century, technology is changing very fast. Most of work is done by high level machinery, businesses and shops are available online. This project provides LED lighting, which is currently the most energy efficient lighting in the market. Also there is combined several features, like color changing and automatic brightness control system to light bulb. Nowadays people like to own multi featured products. There is some room for development as well. In order to stay alive in the middle of competitors, it is necessary to be better, innovative and invest to product development. In future Modular LED Lamp remote control would be improved. For example we would use smartphones, which are very popular among people, instead of remote control. For that is necessary to develop and design application.

Because of widely spread Internet usage, has developed Internet marketing. Internet

marketing or online marketing, refers to advertising and marketing efforts that use the Web and email to drive direct sales via electronic commerce, in addition to sales leads from Web sites or emails. Of course traditional types of advertising like radio, television, newspapers and magazines are still there too. Further more, as people use a lot social media, have developed marketing through social media networks. We have to consider consistent development and create web page and online store to our products, also need to pay attention to different marketing trends.

Legal, ecological environment:

The basic legal environment of a business is controlled and regulated through national, or international law. It is also connected to the political and economical environment which are already explained before. When creating company it is necessary to get trading licence, pay taxes and so on. Luckily many countries are promoting entrepreneurship, creating online registrations for companies and offering financial starting support. Also there are many institutions in several countries who help young people to develop their ideas and to create start ups.

Our world has limited resources, so it is important to be sustainable. LED light bulb is the most energy efficient lighting of existing options. Also our lamp has easy construction to change LEDs, so it not necessary to throw away hole light bulb, you can replace old LEDs to new ones. LED lights contain no toxic materials and are recyclable, also will help reduce your carbon footprint by up to a third. The long operational life time span mentioned above means also that one LED light bulb can save material and production of 25 incandescent light bulbs.

3.2.1 Micro Environment

Microenvironment contains factors that affect a company's ability to serve its customers, such as the company itself, suppliers, marketing intermediaries, customer markets and the public.

Internal:

We are 5 international students from Poland, Estonia, Hungary, Germany and Spain with different background. We have knowledge of logistics, engineering materials, marketing and electrical engineering. We don't have any experience of leading or managing company, as well we don't have large funds to our project development or marketing. At first place

we don't have large scale production, cause at the beginning we need to inform market about our product and to recruit a customer base. It is important that all of us are participating in manufacturing, marketing, advertising and general business. Considering our specializations, we made the departments distribution according to our skills.

Logistics department- Piotr Rzeznik

Product development department- Norbert Ritter, David González Alen

Purchase and sales department- Andra Aedma, Nils Petersen

For production we would need more manpower as well as for other departments like IT, accounting, materials and personnel. Luckily because of the different nationalities we have connections and knowledge how to act in different markets. Which is certainly bonus for startup company.

Suppliers:

Nowadays companies are not focused to a local market anymore, they want to be global. Prohibitions and political barriers are relaxed and global trading has become possible. Further more, the majority of manufacturers are available online. There are a lots of technical products available in different web sites. To develop our project we are using Mouser Electronics and InMotion online stores. In the future it is not definitely a problem to find a supplier. It is possible to choose among different quality, price and reliability.

Intermediaries:

As our main target is B-to-B market, then with bigger projects we would like to make a contract directly with customer. But as we like to be available for regular client too, then we are considering to have partners like lighting and technical stores.

Customers:

Observations of the LED lighting market show a surging LED package market value for lighting application in 2014, in which growths in industrial, commercial and outdoor lighting markets are most evident. Figure 18 is showing in which areas LED market is growing and what are the biggest areas of LED lighting.

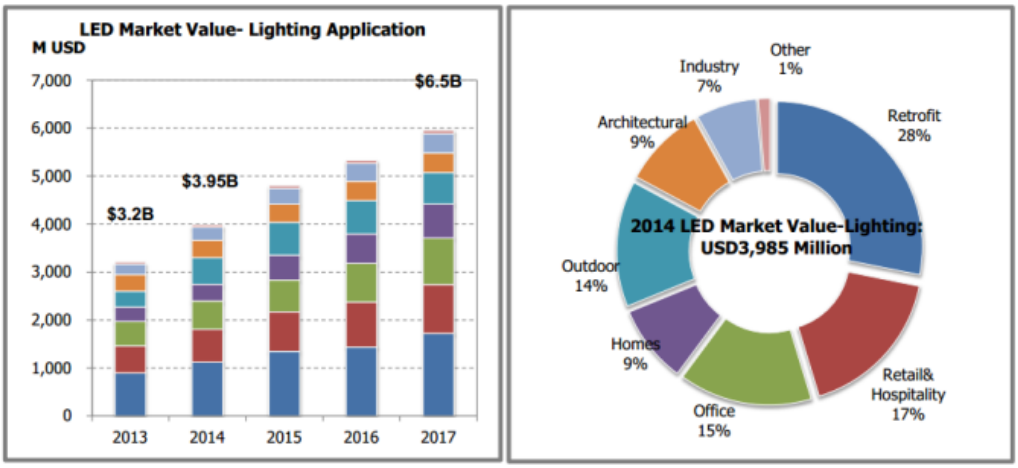


Figure 18: LED market value [64]

As the chart shows, retrofit occupies the biggest part of market. In every kind of business everyone want to be better than competitor, even it means modern lighting. As home usage is only 9% of hole market, then we would rather concentrate to B-to-B market. Our product, Modular LED Lamp, has several advantages comparing to usual light bulb. It changes colors and brightness, fits to universal socket and LEDs are changeable. We would find it useful to use such product in hotels (rooms, hallways, bathrooms), restaurants, pubs, bars, children's play centres, cinemas, clubs, spas, gyms and swimming pools. These are places, where people want to create nice and cozy atmosphere. Comprehensive study of our target market is described in segmentation paragraph.

Market survey

Furthermore we decided, based on our market-analysis, to create a certain market-survey, to understand the customers needs and wishes. To be a successful company, it is absolutely necessary to include the customer needs in the product features and services. In addition to that, innovation, transparency and reaction rate are the attributes which compose a successful company. To achieve this attributes we prepared a market-survey, which aims to find out 5 different tasks to create our own LED and separate the market into different market segments. Questions and answers of the market survey is shown in Figure 19-25.

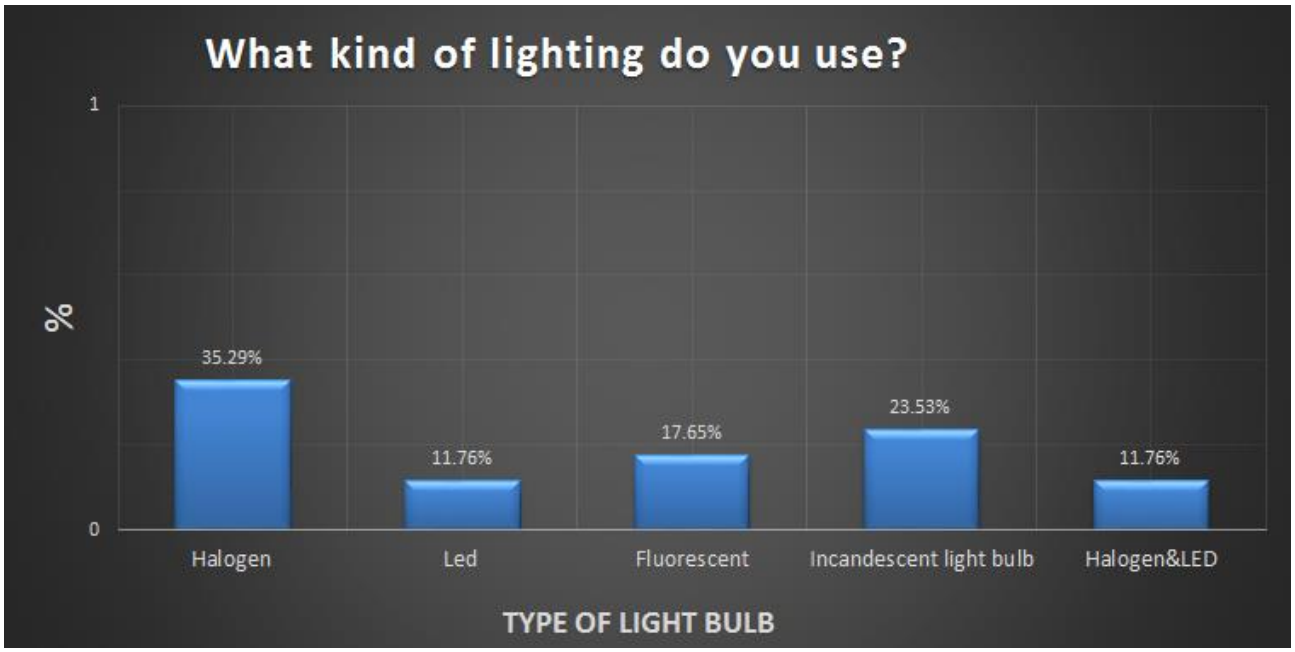


Figure 19: Question 1 Market Survey

Figure 20: Question 2 Market Survey

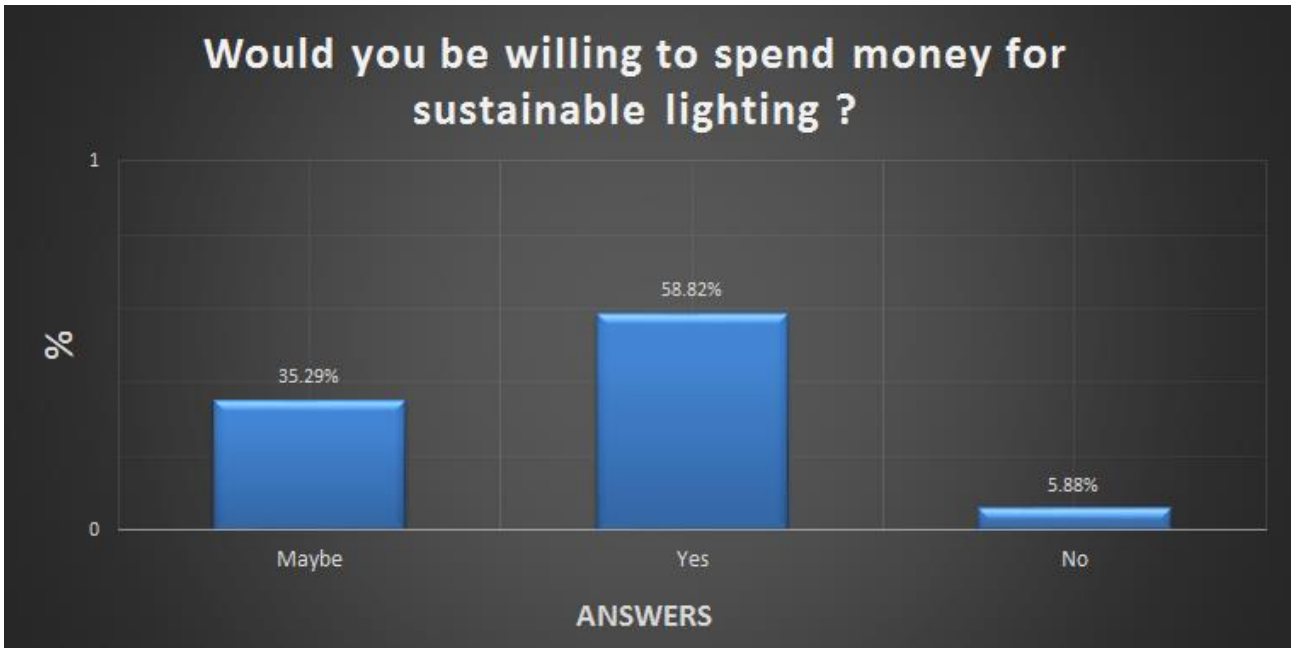


Figure 21: Question 3 Market Survey

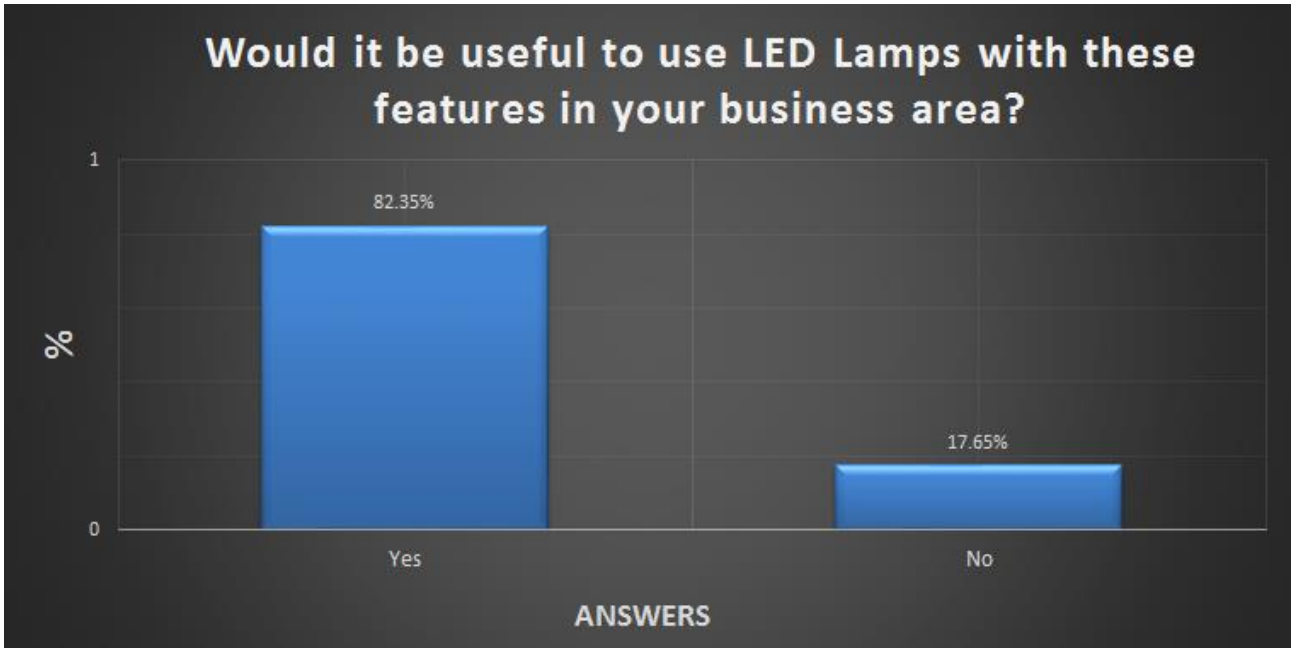


Figure 22: Question 4 Market Survey

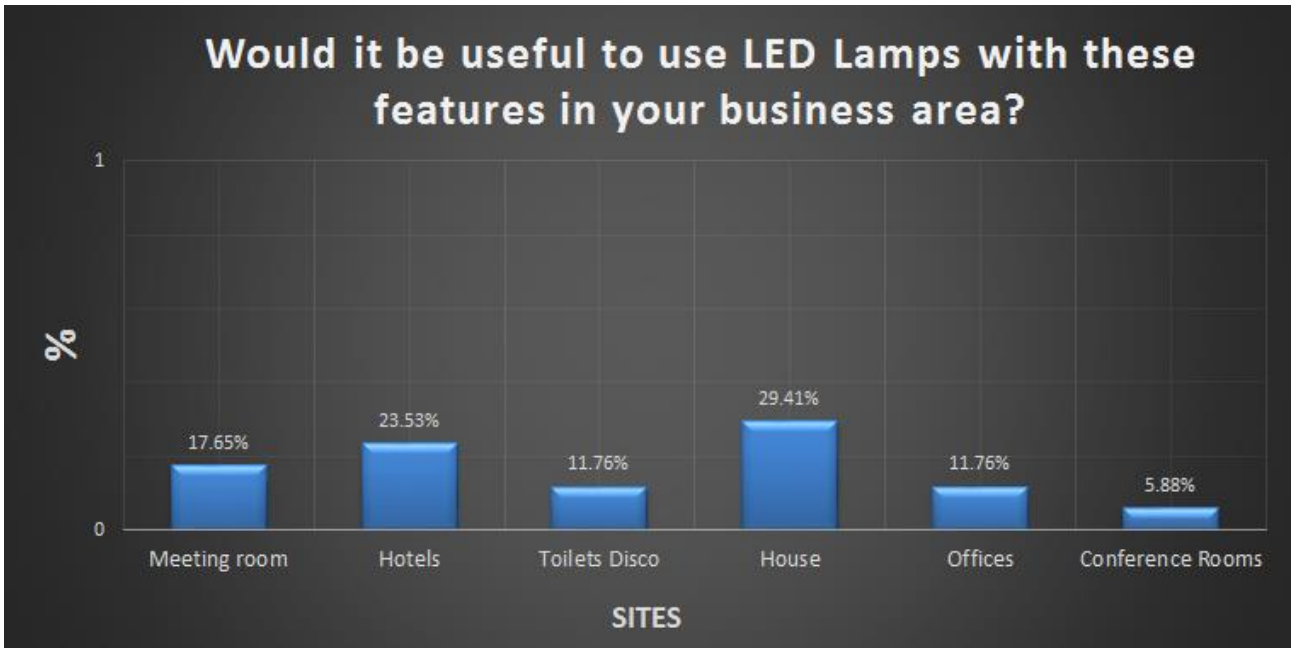


Figure 23: Question 4.1 Market Survey

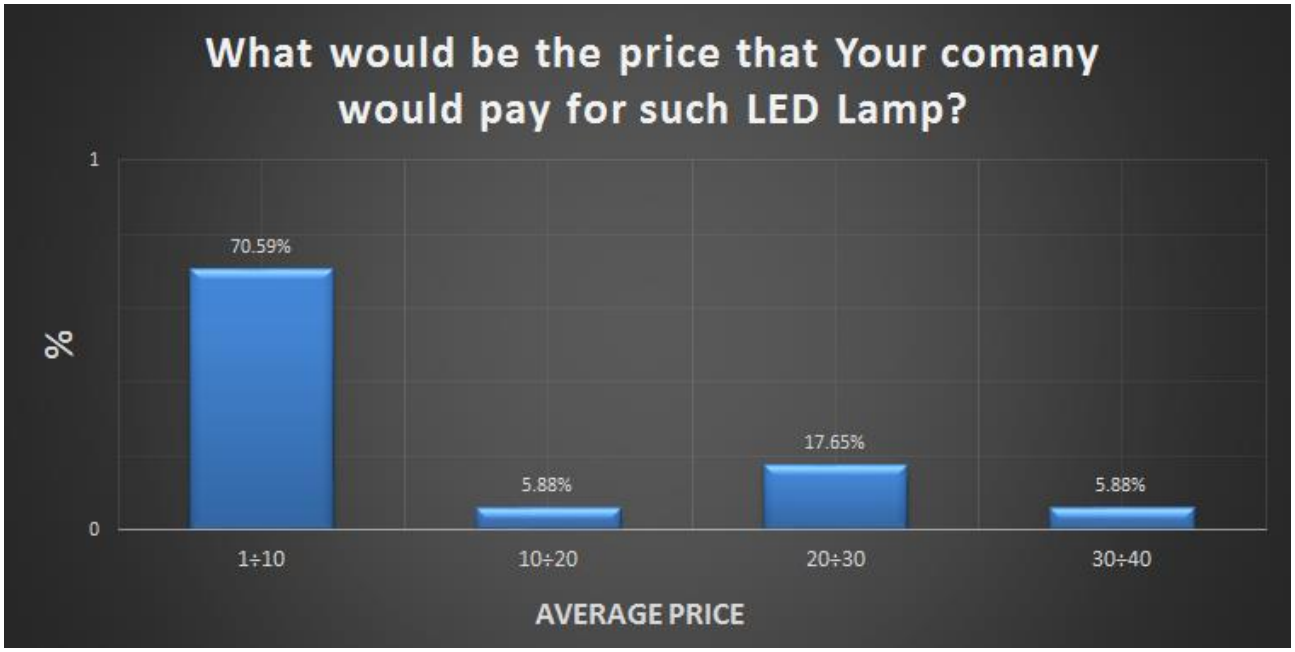


Figure 24: Question 5 Market Survey

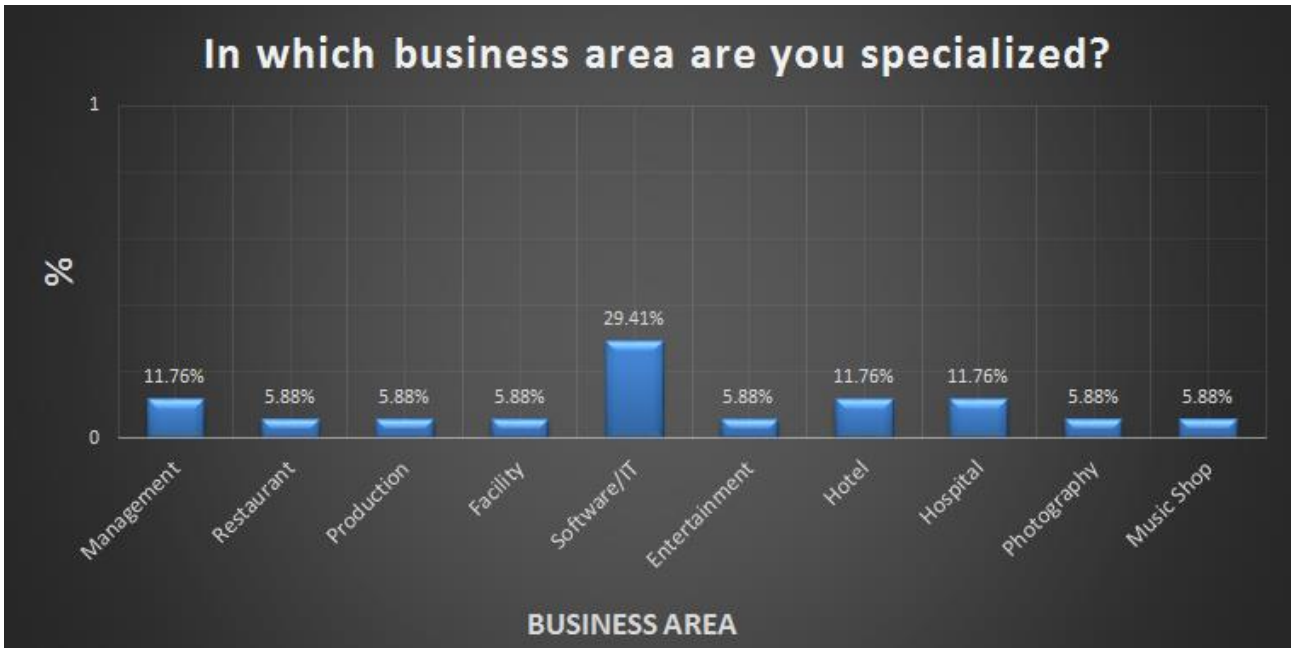


Figure 25: Question 6 Market Survey

Out of this market survey it was possible for us to gain certain information and to create our own market image. As a result of the market survey we found out, that the LED area is an increasing and unexplored market, because exclusive 12 % of our respondent companies are using Led solutions. Many companies are absolutely interested in change the current state to new innovative Led solutions, but they are afraid of spending excessive money. Therefore we decided to create a image with a innovative and not excisting design and developed a new feature (brightness control system) and the price will be between 10-15 €.

Competitors:

In Table 18 there are 7 important LED lighting companies observed, assessed their products and marketing approach, determined their strengths and weaknesses.

Table 18: Competitors analysis

Company	**Product strategy**	**Price strategy**	**Sales support strategies**	**Strengths / weaknesses**
Lemnis Lighting	Lemnis Lighting rely to LEDs sustainability and advantages. They are offering	Registered clients can see the prices in their online store, they see last orders and gets	They sell products in online store, also they have special websites to Australia and Asia.	They have good position in Asian and Australian markets. They have several

	indoor, outdoor and greenhouse LED lighting. In addition Lemnis Lighting combines LED technology with solar power for occasions where there is limited access to electricity.	newsletters. Registered clients have more opportunities compared to regular clients.	Lemnis Lighting promotes it's products through Facebook. They are also available in biggest Asian sales websites.	reputed partners and a lot of media coverage. They have website and online store, all thought it is very difficult to find the place where to register in order to see the prices. Lemnis Lighting haven't been updating it's Facebook profile since 30.10.2012, so there is only old information.
Philips	Philips has many technological products on the market and their approach is to make the world healthier and more sustainable through innovation. In lighting side they are offering indoor and outdoor LED lamps and bulbs for different use. Also they provide	Registered clients can see the prices in their online store, they see last orders and gets newsletters. They have section with promotions and outlet, where are deals of the month and clearance. Philips have 28 days return guarantee.	They sell products in online store. Philips is very active in social media: Facebook, Youtube and Twitter. Posting there information about it's projects, posting there motivating pictures and organizes awarded competitions.	Philips has long history, so there is a loyal clientele and good reputation. They have website and online store. It is easy to register, you can even register through your Facebook account. Website has too much information and it is hard to navigate there. They are not

	car and halogen lighting. In addition to daylight lamps Philips is offering mood lighting and color therapy lamps.			represented in biggest worldwide sales websites.
Osram	Osram want to offer clients modern lighting, energy efficiency and relaxing atmosphere. Osram provides clients mostly indoor and outdoor LED lighting, all thought they have a specialty lighting category, where you can find LED modules and luminaires, aslo LED vehicle lighting.	There are products on the website, put no prices. Also there are no note about online store.	They are sending newsletters to their customers. Osram is represented in social media: Facebook and Youtube. They are posting there newest information about their products and development. Also in their website you can find many applications for mobile phone and a tool what is suggesting you better lighting than you are using currently.	Similar to Philips has Osram long history as well, so there is a loyal clientele and good reputation. They have website, but there is no online store. It is impossible to see the prices of products.
Illumitex	By refusing to settle for the losses associated with secondary optics,	There are products on the website, put no prices. Also there are no note	They are offering personal communication and personal	Illumitex have website, but it don’t have online store. Good

	their breakthrough LED technology incorporates fundamental physics principles to maximize light extraction at the source. Illumitex are offering controlled environment horticultural LEDs, horticultural LED lights for indoor gardening, industrial LED Lighting and architectural LED lighting. Also they are offering LED components.	about online store. When You want to buy something, You can send them e-mail or choose a nearest shop where to find the product. Illumitex are offering newsletter of their products and good prices.	offers. Illumitex is very active in Facebook and Youtube, also clients can find their products in several technical e-stores. Also there have several media coverage.	approach is to communicate with people personally, but still it would be good to see prices. In their website they have posted clients feedbacks, which is good to read in order to getting know the company. Webpage is simple, everything is easy to find, but there are no notes about partners or biggest clients. Their market is oriented basically to the US. All thought Illumitex is active on Facebook, they have only 113 followers.
Sharp	Sharp has two main directions- consumer products, business and industrial products. Consumer	They have different webpage for online store. You have to be registered to buy products. If you are registered then	Sharp has a online store, also company is active in Facebook and has 64201 followers. Sharp introduces	Sharp has loyal clientele, they have been on the market for a long time, so they know what are customers expectations and

	products categories: audio-visual, home office, mobile, home appliances, solar, LED lights, plasmacluster. Business and industrial- office and commercial, solar, electronic components, LED lights, plasmacluster. About LED lighting, mostly they are offering indoor lighting.	you have several advantages like easier order tracking, faster checkout, create and manage your address book, comprehensive view of your order history, quick access to products saved in your shopping cart. Customers mobile telephone numbers are required by Sharps delivery partners so they can arrange convenient delivery dates and also send SMS messages with delivery information.	themselves in fairs and expos. Also there a a lot media coverage of them.	how to act on the market. They have webpage for different countries, as well as online store. At first place online store could be difficult to find, so the webpage structure is not good. They are doing publicity in social media and have had a lots of followers.
Bridgelux	Bridgelux develops high power LED Arrays and Chips in cool, neutral and warm-white lighting solutions. Bridgelux is	Bridgelux has a website where they are introducing their products, but there are no prices. There is list of shops all over the world where you	Bridelux has social media accounts, like Facebook, and they update their page constantly. Sadly, they have only over 500 followers.	Bridelux don’t have online store, difficult to find prices. On website there is no information about partners or biggest clients. They are

	revolutionizing light with LED solutions for retail, home, office and outdoor installations. Connect with knowledgeable teams that can help you be successful with solid-state lighting.	can buy their products. No information about personal offers.	Company is presenting themselves in several technical websites, magazines and newspapers.	more oriented to American market than global (still they are presented in Europe and Asia).
Toshiba	Toshiba has wide product list. They provide computers, tablets, TV and electronics, hard drive and storage, industrial products. Toshiba illuminates the world through lighting technology that is ready for the way we live and work today. They are offering indoor and outdoor lighting.	Registered clients can see the prices in their online store, they see last orders and gets newsletters. There are special offers for registered clients.	They sell products in online store. Toshiba is very active in social media: Facebook, Youtube and Twitter. They have large amount of followers. Company is sending newsletters to their customers. Toshiba is represented in biggest online e-stores, they are participating in fairs and expos. Also press has written about Toshiba a lot.	Toshiba has long history, so there is a loyal clients all over the world, also they have good reputation. They have website and online store which is easy to find and orientate. They know how the market acts, what customers are expecting.

There is also chart of LED Lighting market share (Figure 26):

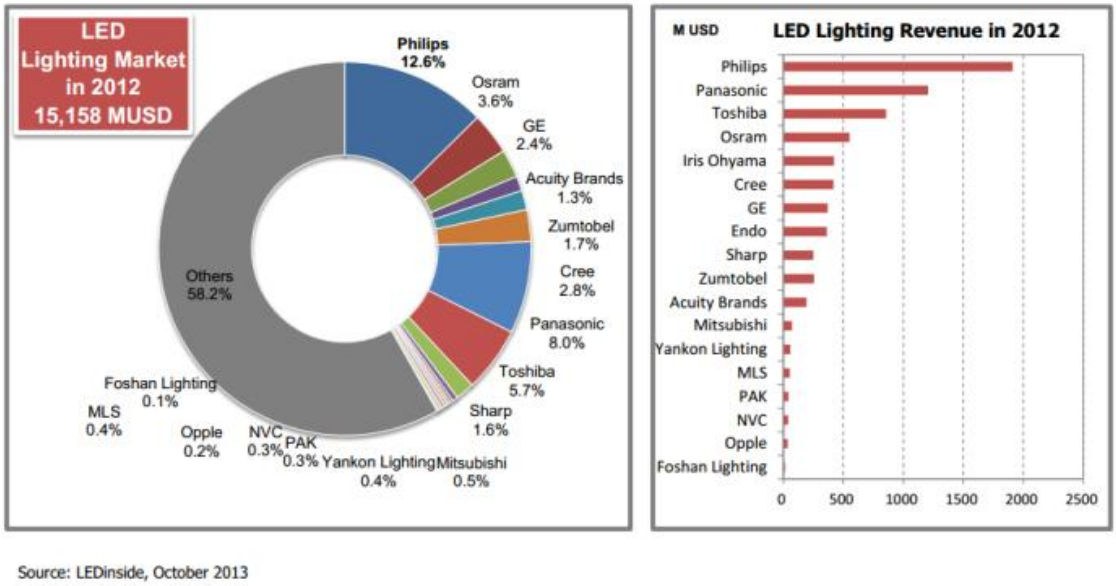


Figure 26: LED Lighting market share [64]

LED lighting industry have developed very quickly in past few years, so there are many strong competitors. Observed companies have been in a market for a while, so they have advantages comparing to us. They have studied the market and already gained customers trust. Comparing these companies products to ours, then Philips is offering the most similar product - mood lighting. Still these products are not totally the same, Philips offers mood lighting lamp, but we are developing universal LED light bulb. Modular LED Lamp has also automatic brightness control system which these lighting companies doesn't offer. We have new feature which might arouse the curiosity of clients. All previously described companies have webpage, but there were no ideal one. Some of them were too difficult, there were too much information or information was missing, online store wasn't findable or did not exist at all. We can learn from the mistakes of our competitors and create simple, but informative website with online store. We are young people with different nationalities, so we can find from different countries partners or institutions who are helping start ups, also we have connections and knowledge our countries markets, which helps us more easily integrate into the market.

3.3 SWOT Analysis

A SWOT analysis includes all underlying information for the two analyzes of the Threats / Opportunities analysis (external factors) and the analysis of the Strengths / Weaknesses (internal factors). The aim of the strengths and weaknesses analysis is to

identify the services and expertise that you can specifically use to your advantage in the competition. This market advantage can help increase customer relationships and further enhance the market position against the closest competitors. It also gives you an overview in which areas you have weaknesses and how to avoid the resulting dangers.

Table 19: SWOT analysis

Strengths	**Weaknesses**
International young company- with different experiences in engineering and manners, international contacts, knowledge of different countries market behavior, various language skills	Do not have loyal customers
(Service) Direct relationship with our costumers	No management experience and sales experience
Lower price concerning the competitors with the same features	Building up a new image
The LED uses less energy	Limited financial methods
(Product) Easy handling and improved recycling	Advertising/Publicity
Opportunities	**Threats**
Increasing market	Market barriers
Subsidy from the government	High amount of similar products
Changing market from Lamp bulb to LED bulb	Strong competitors
Co-operations	

3.4 Strategic Objectives

To make our strategy succeed, we have to define objectives that our organization must achieve.

1. To create well known brand and get 5% of the market share in Europe by the year 2016.
2. To develop client friendly webpage and support system; to develop remote control application for smartphones by the year 2015.
3. Obtain lower production costs to offer clients cheaper products than rivals.
4. Intensity to company ś effort to develop products that our business clients need and want.

5. Boost firms reputation with customers.
6. Become leader in automatic brightness control system introductions.
7. Annual growth in earnings per share of 15%, or better.
8. Achieve net sales growth rate per year of 10%, or better.

3.5 Segmentation

In the marketing analyses chapter we introduced a survey which was carried on in 3 different countries. Among other questions we asked if Modular LED Lamp would be useful in their business area and in which industry respondents acted. Survey showed us, that this kind of light bulb would be useful in many business areas, like catering, entertainment, accommodation, wellness, photography and stores. In the following is a Figure 27 of variety of segmentation variables.

Figure 27: Segmentation

The first variable considered is a business description- Modular LED Lamp, which splits the potential market into catering service, entertainment, accommodation service, wellness service, photography and shops. Then, for each broad group, we brought out special

business areas and places where our product would be useful.

Geographic location

Nowadays people don´t use candles for lighting, due to electricity we are able to use different kind of lighting. Fact is that people around the world are using some kind of lighting, so final orientation would be to get into the international market. To achieve this, we are starting from Europe (if our brand has good position in Europe market it is easier to enter to international market).

3.5.1 Segments descriptions

Catering service

Business area- Companies who are offering catering services to people and organizes various events to customers.

Turnover- Firms turnover don´t have to be very high. Our product is targeted from companies with medium turnover to high turnover businesses. Modular LED Lamp is cheaper than other similar products, it is not a luxury item, rather we would like to see it as a simple commodity.

Products/Services- Restaurants, bars and pubs are definitely buying groceries, furniture, lighting, cleaning service and entertainment service. In these days it is necessary to buy advertising service as well, in magazines, newspapers or web.

Decision makers- Usually company board is making decisions and in final decision owner can express his/her opinion as well.

Frequency of purchase- Most expensive things such as furniture and lighting they don´t buy very often. According to the demand they are buying groceries, cleaning service is used every day and average advertising once a month.

Importance of purchase- Purchase importance is high, cause clients want to have modern, cozy and clean atmosphere, enjoy good food. Also it is important to advertise themselves in order to get new customers. There are big competition in catering service field, so it is important to be better than competitor.

Media use- Our client uses a lot of media in order to advertise themselves in every possible way. They are using Internet, television and also radio.

Values- Catering services values good quality, positive results, hard work, excellence and

team work.

Entertainment

Business area- As we brought out two different entertainment type, then we will describe them separately. Clubs main goal is to entertain grown up people with good music, atmosphere and drinks. Children play centers are providing attractions and funny activities to children.

Turnover- Our product is targeted from companies with medium turnover to high turnover businesses. Modular LED Lamp is cheaper than other similar products, it is not a luxury item, rather we would like to see it as a simple commodity.

Products/Services- Clubs: In clubs very important is lighting system, also they buy furniture, drinks, cleaning service, advertising service. Children play centers: They buy attractions, lighting, furniture, event management service, cleaning service, advertising service.

Decision makers- Usually company board is making decisions and in final decision owner can express his/her opinion as well.

Frequency of purchase- They don´t buy so often, only when needed.

Importance of purchase- It is very important to give best service to customer, so it is relevant that they have all the things they need.

Media use- They are using Internet, various publications, television, radio.

Values- Clubs: They want to provide best service thereby providing best quality products. Children play centers: Positive relationships, learning and development.

Accommodation services

Business area- The main activity is to accommodate people, also they rent out rooms for different events and usually offering catering service too.

Turnover- Usually hotels turnover is medium to high.

Products/Services- Mostly hotels are buying furniture, dishes, technology, lighting, textile, uniforms and so on. They buy cleaning, advertising and designing services. It is very important for hotel to be step forward from competitor, that’s why hotels want to have good quality and something different from others.

Decision makers- Usually company board is making decisions and in final decision owner

can express his/her opinion as well.

Frequency of purchase- Purchase frequency is high, because there are many customers in bigger hotels. Dishes, bedclothes and towels needs to be changed into new ones, rooms have to be tidy, lighting bulbs go out, they have to buy food and so on. Also they need to advertise themselves consistently.

Importance of purchase- Without described products and services it wouldn´t be hotel. It is important that client gets everything he/she needs. Every purchase must have high quality, because with one disgruntled client hotels can loose more than one potential client. By advertising they have to make them visible to public.

Media use- Hotels use media largely. In every day work they use Internet. Bigger hotels are full of t TVs and speakers, also it is possible to read newspapers and magazines there. Also company board is using definitely Internet, for example read business newspapers

Values- To give personalized, warm and consistently exceptional service, memorable experiences for every guest, teamwork and quality.

Wellness services

Business area- Swimming pools: They are providing swimming, bathing and sauna services to people; Spas: They are providing accommodation, swimming, sauna, catering and health services to people; Gyms: Provides work out equipment, personal training and group training to people.

Turnover-

Products/Services- Swimming pool: Furniture, baths, pools, saunas, swimming equipment, lighting, lockers, water, cleaning and advertising service; Spas: Furniture, dishes, technology, lighting, textile, uniforms, waterpark equipment and so on. They buy cleaning, advertising and designing services; Gyms: Free weights, exercise machines, cardio machines, furniture, lighting, cleaning and advertising service.

Decision makers-Usually company board is making decisions and in final decision owner can express his/her opinion as well.

Frequency of purchase-Gyms and swimming pools buys bigger things once in a year or when needed; For spas purchase frequency is higher, because there are many customers in bigger spas. Everyday items needs to be changed into new ones, cleaning service is needed every day, they have to buy food and so on. Also they need to advertise themselves

consistently.

Importance of purchase- Like in every industry you have to beat you competitor with better service or product in order to survive. To offer clients good service you have to have best equipment and good quality products.

Media use-They use Internet, television, radio and other paper publications.

Values- Wellness service values good service and quality.

Photography

Business area- Taking pictures of people or environment.

Turnover- Our clients can be small to big business, cause studios are not usually very big and don´t need so many lamps - so it is affordable for different size and with different turnover companies.

Products/Services- Buys cameras, furniture, lighting, photo accessories, photo printing equipment, design and advertise service.

Decision makers-Usually company board is making decisions and in final decision owner can express his/her opinion as well.

Frequency of purchase- Buys often smaller things, like photo paper. Bigger equipment once a year.

Importance of purchase- In order to have good quality pictures must have good camera and lighting.

Media use- They use Internet, television, radio and other paper publications.

Values-Provide exceptional service and quality, to give best effort to every task, to maintain discipline and make sacrifices in order to achieve personal and business goals.

Shops

Business area- Music shops are selling musical instruments, CDs and vinyls.

Turnover- Small company to big business, cause music stores are not usually very big and don´t need so many lamps - so it is affordable for different size and with different turnover companies.

Products/Services- Buys musical instruments, CDs, vinyls, lighting, advertising service.

Decision makers- Usually owner is making decisions.

Frequency of purchase- They don´t buy very often, depends on customer needs and demand.

Importance of purchase- It is important to provide customer newest and good quality products.

Media use-They use Internet, television, radio and other paper publications.

Values- To provide high quality products and good service.

We are oriented Business to Business segments. We are considering described industries as a target market. In the next chapter we will define our position among competitors and give some explanations about our strategies.

3.6 Strategy/Positioning

Positioning or product positioning is an important aspect of a marketing strategy, particularly when the company acts in a highly competitive market, as our company does. Positioning includes the act of designing the company's product and image to differ the offer from other similar competitive offerings in this market segment. To differ your product from the main competitive products there are the following major positioning categories which are useful to be silhouetted against your competitor. For example positioning by attribute (product feature), positioning by user, positioning vs competition or positioning by quality or price. Therefore we based our positioning on a certain market research and market survey. As result of the market research, we received the awareness that our market includes many and strong competitors. Our strongest competitors in this market segment will be Philips. Philips hold 12,8%, Panasonic 8% and Toshiba 5,7 % market share in this market segment. Furthermore we attained the information out of our market survey, that the most successful positioning will be to differ our product in this market segment with a positioning by attributes and positioning by price. Due to the request of many companies they are willing to change their current state, but exclusively in a certain price categories between 10-20 €. Conclusion of our positioning can be seen in Figure 28.

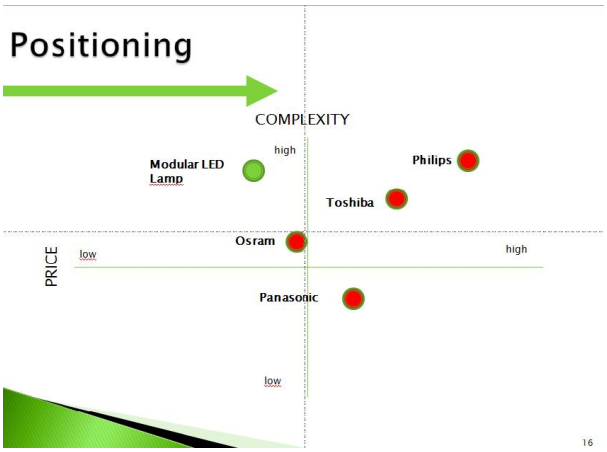


Figure 28: Positioning

This graphic show you the positioning by attributes and prices. As you can see out of this graphic, we are able to compete against Philips relative to the complexity of a product. Furthermore we developed special components, that allowed us to decrease the price dramatically. Through this development we were able to place the product in a successful position to start our business. In addition to that, we decided to reinforce the current state to develop a completely new design of a LED Lamp. The outcome of this is to overcome the market barriers and create a recognizable image and product. Thereby we do not have to compete against other similar products and to convince the consumer behavior. We are able to establish a new advertisement strategy, which stays not in comparison with existing advertisement. The resultant of this is to obtain an advantage against our competitors and to development a successful customer relationship, which will be consolidate trough customer relationship marketing.

3.7 Adapted Marketing-Mix

3.7.1 Product

3.7.2 Price

3.7.3 Promotion

3.7.4 Place

3.7.5 Budget

3.7.6 Strategy Control

3.7.7 Conclusion

4. Eco-efficiency Measures for Sustainability

4.1 Introduction

Sustainability in business represents flexibility over time. These businesses who are connected to healthy economic, social and environmental systems can survive crises. These kind of businesses create economic value and support healthy ecosystems and strong communities. For the businesses, sustainability is not only mere window-dressing. By using sustainable practices, companies can gain a competitive advantage, increase their market share and shareholder value.

To be sustainable in business, firms needs to follow the principles of sustainable development. According to the World Council for Economic Development (WCED), sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Furthermore, over the years „going green“ and „green thinking“ has become less of an option and more of a necessity. Demand for „green“ products increase all the time, so this demand has created major new markets. According to that it is very important to add sustainable activities into manufacturing.

For industrial development to be sustainable, it must address important issues at the macro level, such as: economic efficiency (innovation, prosperity, productivity), social equity (poverty, community, health and wellness, human rights) and environmental accountability (climate change, land use, biodiversity). [65]; [66]

4.2 Environmental

There is one earth, where are limited resources. Every kind of manufacturing activity or some product usage has influence to the environment. Of course it is impossible to produce something with no impact to the environment, but using sustainability principles it is possible to be less harmful. This paragraph is discussing ways of making LED light bulb mass production more sustainable.

First of all, every product is made of something, so it is necessary to have some materials in production. In order to be more environment friendly it would be good to use recycled materials. It is wrong to think that recycling has no effect on the environment, there is a carbon cost to recycling although it is less than manufacturing a new item. If company is

carbon neutral they are offsetting the amount of carbon dioxide they produce by providing a positive impact on the environment. Connecting recycling to Modular LED Lamp it is not possible that all materials are recycled. In LED Lamp there are a lot of miniature technology which is not recyclable, vice versa they are hazardous. Still some parts of LED Lamps are recyclable, like glass, aluminium and circuit boards, phosphor powders which contains rare earths and mercury; plastics. According to that information it is possible to use recycled aluminium for the socket, glass or plastic for the bulb and circuit boards. Thinking about packaging and manuals it would be relevant to use recycled cardboard and paper.

As this project requires to use hazardous materials it is necessary to pay attention to RoHS symbols. Any RoHS compliant component is tested for the presence of Lead (Pb), Cadmium (Cd), Mercury (Hg), Hexavalent chromium (Hex-Cr), Polybrominated biphenyls (PBB), and Polybrominated diphenyl ethers (PBDE). For Cadmium and Hexavalent chromium, there must be less than 0.01% of the substance by weight at raw homogeneous materials level. For Lead, PBB, and PBDE, there must be no more than 0.1% of the material, when calculated by weight at raw homogeneous materials. Any RoHS compliant component must have 100 ppm or less of mercury and the mercury must not have been intentionally added to the component. [67]

When buying materials it is important to buy in bulk, because of the transportation energy. Also it is would be important to buy local (if possible) – transportation energy is smaller and local people have work.

Secondly, in order to have more efficient production there is great importance to use new technology, usually newer technologies are more energy and work efficient, so it is possible to save money, time and environmental resources. It is vital to develop production, but also it is important to follow responsible and eco-friendly behavior in company´s every day actions.

Further more, to reduce the footprint of the product it is reasonable to use ecologically friendly transportation. For example to use hybrid trucks or electric trains. Also it is important to transport products in bulk.

When mass producing Modular LED Lamp these points have to be considered to be more sustainable and eco-friendly.

4.3 Economical

4.4 Social

Definition

"The ability of a community to develop processes and structures which not only meet the needs of its current members but also support the ability of future generations to maintain a healthy community." [68]

Social sustainability means that work within a society and the related institutional arrangements:

- satisfy an extended set of human needs
- are shaped in a way that nature and its reproductive capabilities are preserved over a long period of time and the normative claims of social justice, human dignity and participation are fulfilled. [69]

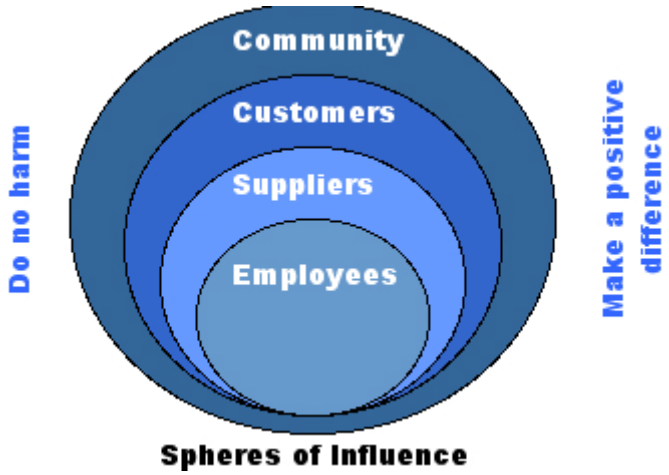


Figure : Social sustainability spheres of influence [70]

Nowadays, the social sustainability is important way of management which takes care of meeting the expectations of customers and employees, maintaining quality relationships with their partners and local communities. Thanks to such approach, it is possible to add the value to whole supply chain by increasing the productivity indexes, company reputation, minimising production cost and, by the way, reducing harmful impact on the environment.

Gross National Happiness

This index illustrates the prosperity of national society in more holistic terms and measures actual wellbeing, rather than consumption. By contrast, the conventional concept of Gross

National Product (GNP) measures only the sum total of material production and exchange in any country. [71]

Supporting the society

As a social responsible company, it is important that indigenous dwellers should be the main workforce in the manufacturing system. When we stimulate local community and cooperate with local suppliers, we raise the quality throughout the entire value chain. We can gain the favour of the municipality governing body, press corps and people associated with science. The company can participate in a number of social activities, such as sponsoring the cultural and sport events, supporting animal shelters or planting trees in the residential area.

Lighting has a positive effect on greater sense of safety and aesthetic of the public spaces while lower environmental impact.

The LED lamp manufacturer can fit into this ideas, for example, by providing a lighting for one of pets from a town zoo, fund the equipment for university electrical laboratory or rent the stage lamps to organiser of a charity concert.

Care about surrounding

Big factories generate a lot of wastes and unpleasantness. The main goal is to reduce the nuisance to the populace which comes from the industrial plant (pollution of the environment in which they live, no unpleasant odors in the atmosphere, access to clean and drinkable water, dense smoke around the city, disturbing the peace by industrial noises). Workers would like to take a rest in calm after spending many hours in factory, so that is very important to take care about their living conditions.

The best solutions are minimising the impacts of production for environment by using the non-toxic materials and depuration of the air outgoing from factory.

Well-being of customers

The advantage of using Modular LED lamp is the ability to create a specific atmosphere, for instance, for romantic evening together. This is a power of mood lighting which can be used for guests of hotels or restaurants. Additionally, it is performed with a minimal power consumption and enhanced efficiency.

Demanding customers can gain improved conditions for learning, reading books. First of all, the visibility increases.

Employees healthcare and working conditions

The most important issue for every industrial plant is to care about health of workers. Companies should improve quality of working conditions continuously. They should

design ergonomic workstations, provide their employees with Occupational Health and Safety training and perform health safety programmes.

If inside the plant, there are working many noisy appliances, the personnel should have workwear, earmuffs or earplugs.

Industrial hygienics is very important problem to be considered by the plant owner. It affects the well-being, health and productivity of the employed staff. In the future, it can prevent the occupational illnesses.

Workplace training should be performed to show proper way of using the machines and to prevent the potential accidents. Production engineers can implement some best practises from manufacturing experts, such as *poka-yoke* (mistake-proofing) or redesigning the workplace in order to be more efficient and much safer.

Respect for people is crucial matter, because everyone wants to be treated fairly. Companies should have implemented the protection of workers' rights policy.

Employees are counting on the job security and fringe benefits, for example, severance package, trainings, holidays or shares in a company.

They wants to have the guarantee of their job with long-term fair agreements with legally regulated working hours.

Consistent improvement of skills

Factories have to provide their workers with trainings to keep improvement of professional qualifications. Japanese philosophy called *kaizen* (continuous improvement) enables to educate the leaders who thoroughly understand the work, live the general concept of business and are be able to teach others. LED lamp production requires employees who are well prepared for the job. For management staff there are required engineering and electrical knowledge.

The company is able to succeed when her crew is well motivated for better work and enabled to further professional development. They have to derive satisfaction from their work.

Equality in diversity

Main issues of equality:

- provide diverse work environment,
- equal opportunities, fair treatment without regard to race, beliefs and other prejudices

- better representation of women in leadership roles
- recruitment of trainees, students, people with disabilities
- various suppliers

Corporate culture

Companies should put on:

- consent to third-party audits, certification
- transparency, publication of the reports presenting dangers that occurred; not hiding inconvenient data
- maintenance of standards, implementation of ISO policies
- open dialogue with employees
- human rights respect, especially when it is used the labour force from Asian countries (LED supply chain often reaches to this region)
- offering well paid, decent work

Summary

Social responsible company is able to:

- improve the organization, taking care of the development of their own people and partners
- develop outstanding people and teams performing general concept of the company
- gain the respect from wide network of partners and suppliers.

Integrity and diverse working conditions pull us together and have a positive effect on energy consumption and general mood.

Thanks to social responsible investments, companies can maximise their profits over long-time period.

4.5 Life Cycle Analysis

4.6 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

5. Ethical and Deontological Concerns

5.1 Introduction

Figure : Business ethics cloud [72]

Ethical problems concerns many aspects of everyday life. Lighting is one of them. *Lux* is an inseparable part of human, animal and Earth co-existing. Our project deals with the artificial lighting, which is very important as well as the natural one. Each of us needs a well-lit working, living and study conditions.
As a result, people feel better and achieve more satisfying scores.

We need to focus on all implications of the ethical issues that are related to product development, proper production system, marketing strategy, legal aspects and environmental impacts. These ethical issues are very important and can not be missed because it is necessary to care about position, reputation and future condition, not only the current profits.

> "A reputation for ethical decisions builds trust in business among business associates and suppliers. Strong supplier relationships are critical to a successful business." [73]

Ethics help us to make us better people just because it is based on the philosophical examination of particular issues in private and public life that are matters of moral judgment.
Thanks to that, we can use philosophical methods to identify the morally correct course of action in various fields of human life.

5.2 Engineering Ethics

What is an engineering ethics?

Engineering ethics is study of moral issues and decisions confronting individuals and organizations involved in engineering, also considered as a study of related questions about moral conduct, character, ideals and relationships of peoples and organizations involved in technological development. [74]

Ethical behavior deals with making business decisions based on an established Code of Ethics. Employers should write their own code of ethics which can serve as a framework for supporting decisions to be made by them and employees.
In case of building the LED bulb, we need to be sure that our product will fulfil the demand and the final customer will not feel deceived.

There are few ethical problems that are connected with lighting market and deals with engineering:

- life-duration: limitation of turn-on cycles,
- not obeyed EU directives,
- lack of important technical information in catalogues, leaflets, user manuals,
- respect the principles of intellectual property, patents for inventions and designs.

These issues need to be considered during creating professional code of ethics for our project. There are plenty of universal policies created by worldwide engineering associations which can be easily adapted in multinational environment.

Code of Ethics

We would like to use some rules created by Institute of Electrical and Electronics Engineers (IEEE) that are setting the duties in relation with colleagues, engineering community and also for customer:

- To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment.

Engineers are responsible for their decisions, because they create objects which are used by other people (electronic appliances, other devices). If someone noticed any defect in existing system which could be harmful for environment or society, it should be announced

to the public immediately. Never try to withhold such information.

- To be honest and realistic in stating claims or estimates based on available data.

Transparency is a key aspect of trust. Our client wants to know what he is buying, how does it work and what are the limitations in usage.
This sentence applies also to the relations between employees.

- To improve the understanding of technology; its appropriate application, and potential consequences

Employees should share their knowledge with others. The employers should provide the trainings in order to have well-educated staff. That issue can be also connected with providing our clients full technical specification of product. User manual should contain all information relevant to the finished product and instruct, how to proceed in case of malfunction. When the customer understand action of product, he will be able to use it longer without a flaws.

- To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations

Wrong help can hurt - we can support only if we really know what we are doing. Taking part in extra courses (self-development) or projects is recommended, but it should be done in proper way, in compliance with our health conditions, skills and interests.

- To treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression

Treat another person the same way that you expect to be treated. As an employer we should provide our staff equal opportunities. We have to provide our employees a fair work and remuneration, as well as safe and healthy working conditions, stimulating the creative attitude, self-discipline and openness towards other people. It should be in force without regard for employee's origin, colour of skin, etc.

- To avoid injuring others, their property, reputation, or employment by false or malicious action.

This is very important to remember that we are not alone and our improper operation can damage other person. Specially, if we are working in the production line. In many

countries companies are obliged to make a training of Occupational Safety and Health and fire prevention regulations. Thanks to that, the employees are aware of the possible threats.

- To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others.

  To assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

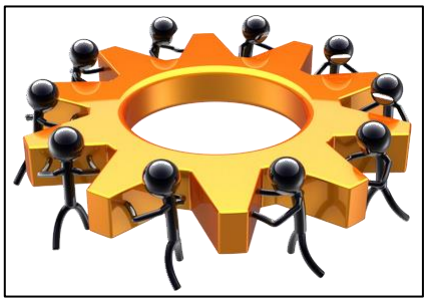


Figure : Cooperation [75]

We are aware that various people can have different problems. That is why we should be open-minded, helpful and provide advice if it is needed. What is important, criticism should be accepted with humility. Do not hesitate to correct the mistakes of your co-workers when someone does not perceive it. If we cooperate as a team, we can gain a "synergy effect" and then, a performance will increase significantly.

[76]

5.3 Sales and Marketing Ethics

Launching the product into the market has to be preluded by the deeply analyses of opportunities and threats. In the Marketing part of our project we did a research in which we got known the main competitors and we compared existing models of lamps in terms of not making fakes. There were also examined customer needs.

The most important ethical issue is that competitors should respect trademarks of other companies and don't manufacture false products.
We have made every effort to respect the registered brands. We had to create our own trademark which will distinguish us and will be associated with a brand. Our logo is not a copy nor refers to the appearance of the existing one. We have to avoid unfair competition.

Figure: Agreements [77]

For our customers it is important to get a product which is comply with advertised guarantees. We are the opinion that people deserve an utmost esteem and the companies should provide the good of our community.

In case of light bulb market the common practice of companies is relatively short warranty period for lighting equipment. Guaranteed period is much lower than the assumed life of the bulb.

The problem of this area could be also a market supremacy of big companies (GE, Philips, Osram), which hold all the cards. It can be a barrier for running new business and developments and lead to misconceptions or overuses.

Sellers politics consisting in overstate the lighting parameters or intentional lowering power consumption has become a standard in the majority of retailers who offer their products on the Internet.

Our code of ethics will include these sentences:

- Providing customers with high quality products.
- Developing relationships with clients that go beyond the mere sale of a product and is based on an honest dialogue.
- Respect and appreciation of all stakeholders, taking care of their well-being and possibly for its multiplication, in order to win their trust.

5.4 Academic Ethics

Working in groups requires mutual respect, understanding and trust. As a result, we are able to support ourselves at every step. Each of us is a student coming from different academic background and everyone contributes a part into project.

When we are using someone else's intellectual property, we always make a source footnotes. The same applies to borrowings used in the bibliography, like graphics, surveys, studies and analyses.

Academic ethics deals with tribute to existing patents, inventions, designs and developed projects. We can not infringe the terms of use of external materials which we are basing on.
In each case regarding to this project, we are using the references in educational and non-commercial purposes. What is more, we are using an open-source software to avoid computer programs license problem.

As a part of student community we have rights and responsibilities. Sentences below are the examples of a negative behavior in this community.

Plagiarism is intentionally or unintentionally using someone else's words or thoughts, without giving proper credit.

- A direct quotation must be acknowledged and documented properly. The sources of information must be outlined in a list of works cited.
- The source of all paraphrased or summarized material must be acknowledged.
- The work of others, whether in the form of ideas, laboratory results, artistic work, computer programs, etc., must be acknowledged.
- False or misleading citations of sources constitute plagiarism.

Cheating is attempting to present as one's own, work that one has not performed, or using improper means to pass an examination.

- Falsification of research data
- Student may not submit work she has not done herself, including papers, projects, homework assignments, computer programs

[78]

5.5 Environmental Ethics

Nowadays, many people think in category "here and now". It is not proper behavior for condition of environment and for all the society.
We cannot forget that we are not the only people on this globe. Next generations also

would like to live here in calm and benefit from all the goods of our planet.

Eco-friendly and sustainable development are the popular issues that are related to climate changes and global warming. Hence, there might begin an ethical problem, when the companies will abuse operating empty slogans, applied to environment, without coverage in reality, figures, results etc (double talks).

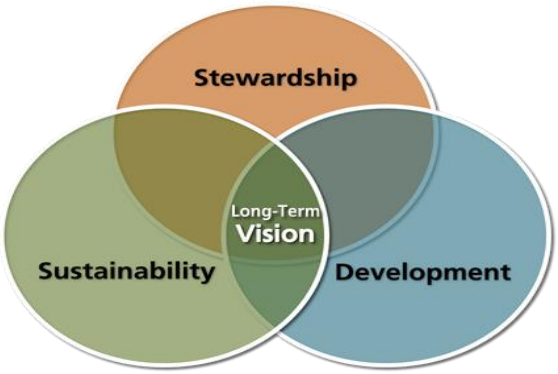


Figure : Environmental stewardship [79]

Modern factories should have minimize CO_2 emission, for example by using filters on chimneys. There are plenty of harmful materials using in lighting sector, like mercury, which should be reduced in material list. Company can introduce Environmental Stewardship schemes in order to act in responsible way for community and green fields. It is a long term investment which will bring yields in the future.

"Environmental stewardship is the responsibility for environmental quality shared by all those whose actions affect the environment." [80]

Policies for producing the light bulbs:

We are not using harmful materials.

We take care of recycling policy.

We are going to act with due diligence to the recycling policy. Final product boxes will be designed from recyclable cardboard which is friendly to environment.

5.6 Liability

LED lamp, like most of electrical devices, may be harmful for health condition of final user. In the leaflets we will publish detailed information about the proper use of the appliance in order to not cause any damage.

We cannot stretch the health requirements. We have to be responsible for our workers

assembling the lamps. We need to produce in comply with European Union restrictions and other international standards.

Energy labels

The European Union (EU) Energy Label rates products from A to G in terms of energy consumption, with A being the most efficient and G being the least efficient. By law the label must be shown on all light bulbs. [81]

CE mark

It is also obligatory to mark all the LED bulbs with a Conformité Européenne sign. The CE marking indicates a product's compliance with EU legislation and so enables the free movement of products within the European market. [82] Unethical aspect in lighting market is counterfeiting of European Union CE mark by China Exporters.

5.7 Conclusion

Applying ethics policy benefits to many companies because they are better perceived either by people beyond the company (clients, customers, contractors) and the employed staff who will feel worthily. Pleased and well-motivated employee is the one who is treated humanely, not exploited, receives remuneration at time and sees growth opportunities ahead. According to the golden rules of ethical company, if firm wants to take care of the welfare (profits, further investments), it is needed to put on trust, honesty (transparency) and respect the privacy of individuals.

Many companies use rules of proceeding in the relationships between employees and that is why they have numerous Labour Codes regulating approach to people. Most of these sets of rules are developed basing on the thoughts of people dealing with ethics professionally. Principles make it easier to communicate among ourselves and achieve our goals, without disturbing to other people. This establish an order in interpersonal life. In addition, when manners are standardized, it is simpler to obey them. Therefore, we all claim that ethics is necessary in human life and is very effective investment.

Company goal should be to achieve financial success at demonstrating concern for the natural environment and the sense of responsibility to society.

When we are acting in ethical way, we not only succeed, but also we will be able to have some use of it. After we get the peak of popularity or money it would be great if we could

share it with others, not staying alone. We have to remember it during project development and our private and professional life.

6 Project Development

6.1 Introduction

In this chapter is introduced Modular LED Lamp design and prototype development which is compatible with actual lamps. Overview of architecture, components and functionalities. Also final results of tested products and some ideas to future development.

6.2 Architecture

PCB

To create Modular LED Lamp we need to develop LED driver (PCB) schematics. PCB is an interactive printed circuit board editor for Unix, Linux, Windows, and Mac systems. PCB includes a rats nest feature and schematic/netlist import, design rule checking, and can provide industry standard RS-274X (Gerber), NC drill, and centroid data (X-Y data) output for use in the board fabrication and assembly process, as well as photorealistic and design review images. PCB offers high end features such as an autorouter and trace optimizer which can tremendously reduce layout time. [83]

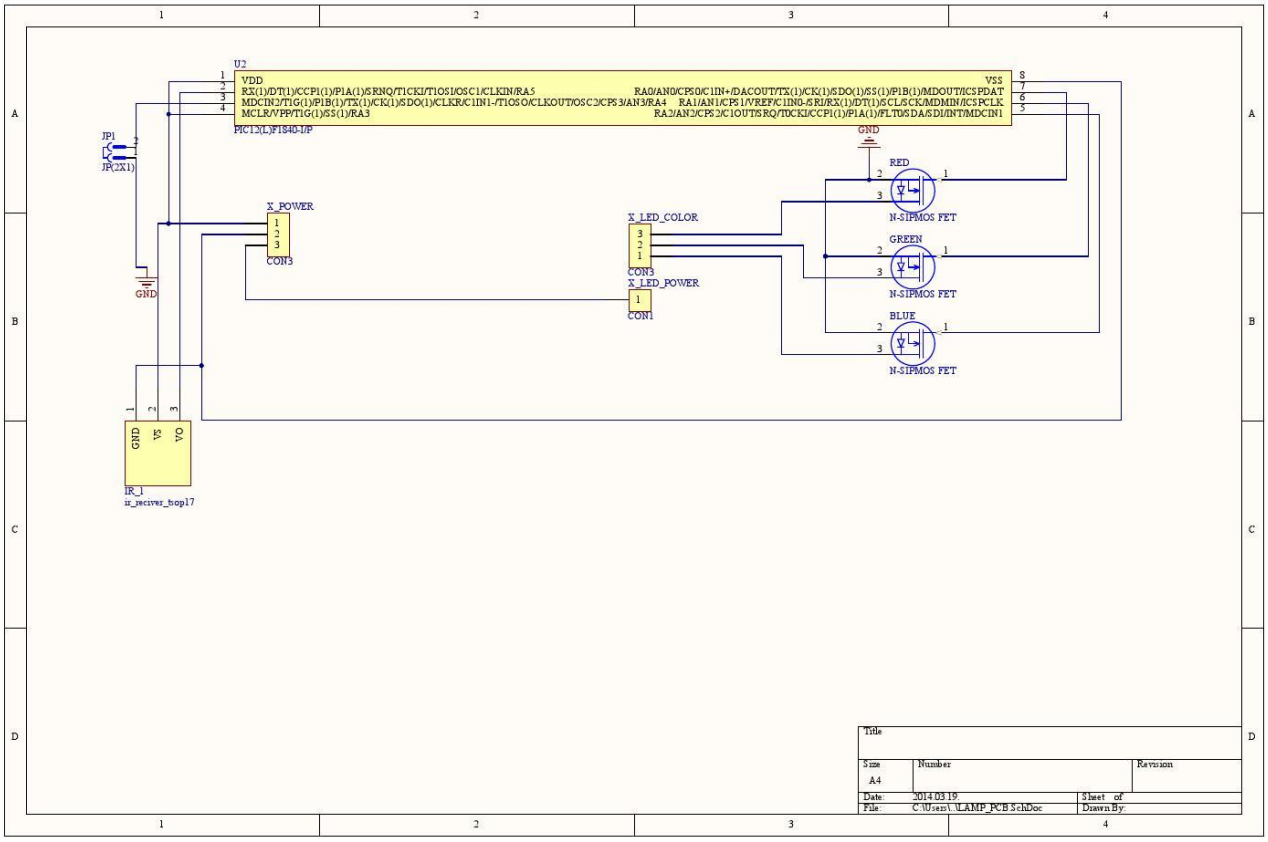


Figure 27: Schematics PCB

In the Table X there are components of LED Lamp PCB. Contains component pictures, quantity, name and description.

Table X : PCB LED Lamp

PCB LED LAMP			
Picture	Quantity	Name	Function
	1	Microchip	It is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.
	3	LEDS	A light-emitting diode (LED) is a two-lead semiconductor light source that resembles a basic pn-junction diode, except that an LED also emits light
	1	Power supply	A power supply is a device that supplies electric power to an electrical load. The term is most commonly applied to electric power converters that convert one form of electrical energy to another
	1	Ultrasonic sensor	Ultrasonic sensors work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively.
	3	Mosfets	The metal–oxide–semiconductor field-effect transistor MOSFET is a transistor used for amplifying or switching electronic signals.
	3	Connectors	It is a device for joining electrical circuits as an interface using a mechanical assembly
	1	IR receiver	This device receive IR waves from remote controller

For better visual overview Figure 28 shows design of LED PCB and Figures 29-30 shows 3D pictures of designed PCB.

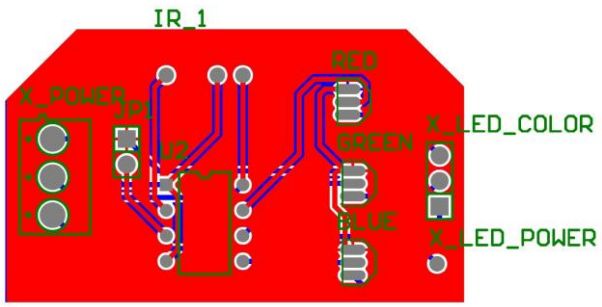


Figure 28: PCB LED

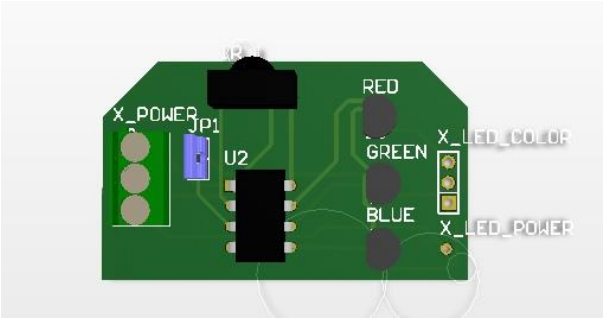


Figure 29: 3D Simulation

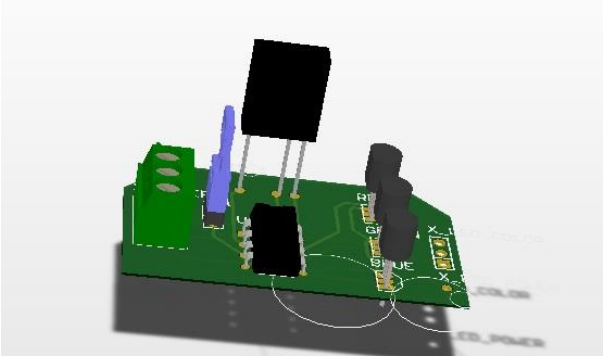


Figure 30: 3D Simulation

Remote control

As it was necessary to do schematics to PCB, it is necessary to do circuit design to the remote control too, so it would work like required.

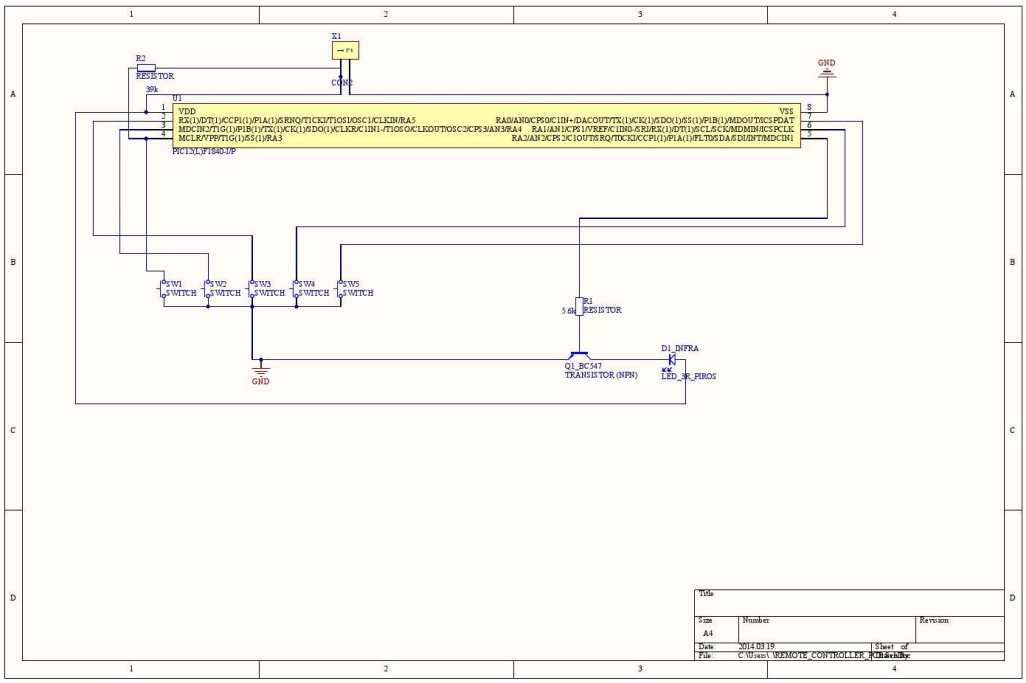


Figure 31: Schematics Remote Control

In the Table Y there are components of PCB remote control. Contains component pictures, quantity, name and description

Table Y: PCB remote control

PCB REMOUTE CONTROLLER			
Picture	Quantity	Name	Function
	1	Microchip	It is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.
	1	Transistor	It is a semiconductor device used to amplify and switch electronic signals and electrical power.
	1	Battery	It is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy.
	2	Resistances	Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits
	5	switch	It is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another.
	3	Connectors	It is a device for joining electrical circuits as an interface using a mechanical assembly
	1	IR LED	Infrared (IR) light is electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nanometres (nm) to 1 mm.

For better visual overview Figure 32 shows design of remote control PCB and Figures 33-34 shows 3D pictures of designed PCB.

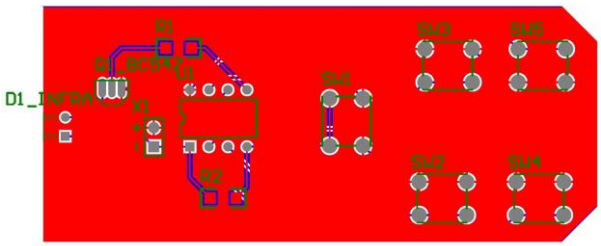


Figure 32: PCB Remote control

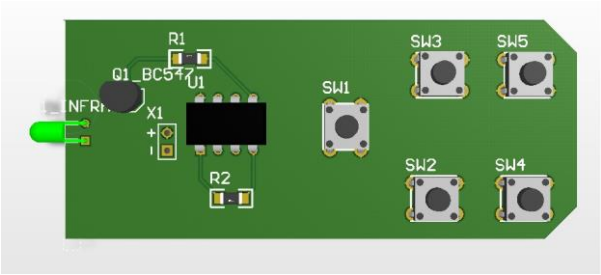


Figure 33: 3D Simulation Remote control

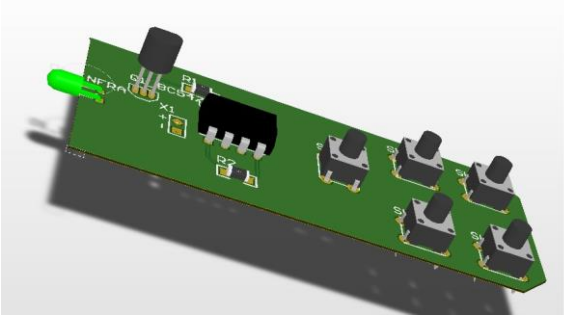


Figure 34: 3D Simulation Remote control

Manufacturing files

In the following are manufacturing file pictures for LED Lamp PCB and remote control PCB.

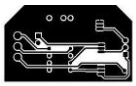


Figure : Bottom LED Lamp PCB

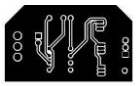


Figure: Top LED Lamp PCB

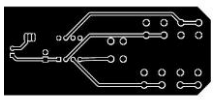


Figure : Bottom remote control PCB

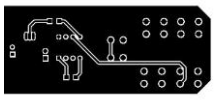


Figure: Top remote control PCB

In Table Z there are some calculations about maximum current, voltage, capacity and so on

considering the specific circuit design.

Table Z: Calculations

Calculations	
PCB-Printed Circuit Board	70 µm layer thickness
Maximum current	0.5 A
Minimum track width	2.3 mm
Resistance	217 mΩ
Voltage	108 mV
Capacity	54 mW

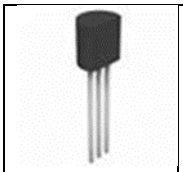
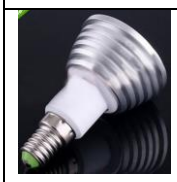
Consumption of the Circuit in sleep mode is around 35nA

6.3 Components

To make a Modular LED Lamp we will need several components and materials. In Table M there are showed needed materials, quantity, company and description.

Table M: Material list

MATERIAL LIST						
Picture	Quantity	Reference	Company	Description	Data sheet	Price
	2	PIC12F675-E/P 579-PIC12F675-E/P	Microchip Technology	Microcontroller de 8 bits - MCU 1.75KB 64 RAM 6 I/O Ext Temp PDIP8	Data Sheet	1.06 €
	3	2N7000 512-2N7000	Fairchild Semiconductor	MOSFET N-CHANNEL 60V 200mA	Page 487	0.34 €
	1	651-1757255 1757255	Phoenix Contact	Pluggable Terminal Blocks 3 Pos 5.08mm pitch Through Hole Header	Page 1.423	0.72 €
	1	651-1934874 1934874	Phoenix Contact	Pluggable Terminal Blocks 3 Pos 5mm pitch Plug 26-14 AWG Screw	Page 1.417	0.45 €
	1	651-1945106 1945106	Phoenix Contact	Pluggable Terminal Blocks 3 Pos 3.5mm pitch Thru Hole Pin Strip	Page 1.418	0.15 €

	1	833-BC547B-AP BC547B-AP	Micro Commercial Components (MCC)	Transistors Bipolar - BJT Med Pwr Biplar Trans 45V, 100mA	Data Sheet	0.36 €
	1	STEVAL-ILL037V1	STMicroelectronics	90 V a 265 V	datasheet	36.00 €
	5	611-PTS645SL432 PTS645SL43-2 LFS	C&K Components	4.5 x 4.5 mm footprint 0.55 mm height Top actuated Gullwing termination	Data Sheet	0.11 €
	1	696-SSL-LX5099IEW	Lumex	Infrared, Red 940 nm, 635 nm 20 mA 1.4 V, 2 V	Ficha técnica	0.536 €
	1	TSOP1738TB1	Vishay	38 kHz 35 m 4.5 V to 5.5 V 5 mA	Data Sheet	0.536 €
	1	link	Arduino	5 V 2 mA 2 cm - 4cm		1.33 €
	4	link	Kingbright	LED estándar - a través de orificio RGB 630/525/465nm 750/420/750mcd 60deg	Data Sheet	1.22 €
	1	link	China	4w	Specifications	0.99 €
	1	link	Pccablenet	3V CR2032		1.25 €

	3	link	CHINAv	Ω		0 .09

IR

There are a number of consumer Infrared protocols and they have been used for every single purpose possible, like PDA laptops and other consumer appliances. RC-5 & RC-6 by Phillips , RCA are few examples of consumer IR protocols.

In this demonstration we will stick the to NEC protocol by NEC corporation,

NEC Infrared Protocol [84]

- A 9ms leading pulse burst (16 times the pulse burst length used for a logical data bit)
- A 4.5ms space
- The 8-bit address for the receiving device
- The 8-bit logical inverse of the address
- The 8-bit command
- The 8-bit logical inverse of the command
- Final 562.5µs pulse burst to show end of message transmission.
- Logical '0' – a 562.5µs pulse burst followed by a 562.5µs space, with a total transmit time of 1.125ms
- Logical '1' – a 562.5µs pulse burst followed by a 1.6875ms space, with a total transmit time of 2.25

The transmission of 0 and 1 is shown in the Figure G below :

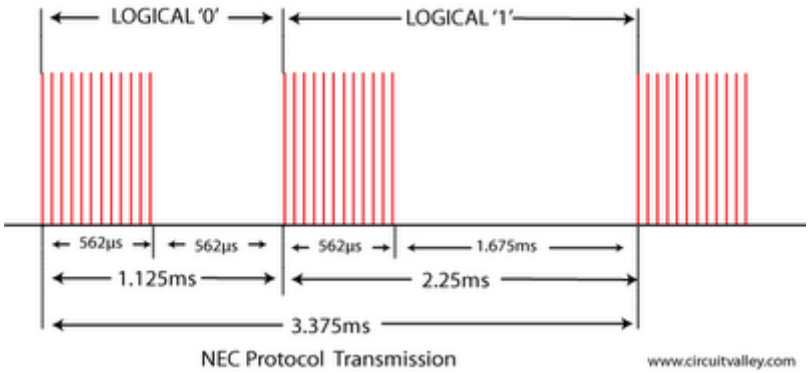


Figure G: Transmission [84]

There are four bytes of data bits are being sent in least significant bit first order the figure blow shows the format of an NEC IR transmission frame, for a command of 0xB1 (10110001b) and an address of 0x8D (10001101b) .

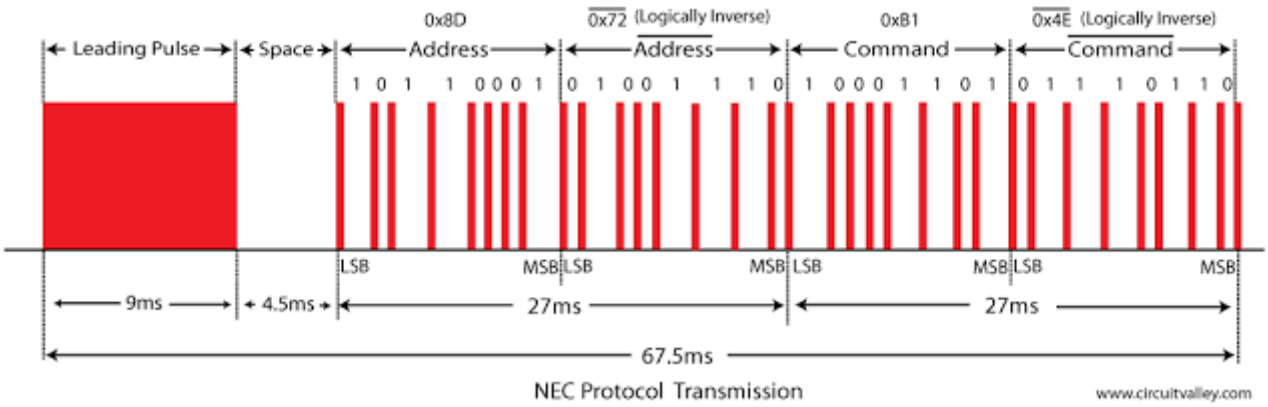


Figure H: Transmission 2 [84]

16 bits for the address (address + inverse) require 27ms to transmit time and the 16 bits for the command (command + inverse) also require 27ms to transmit time, because address + address inverse or command+command inverse will always contain 8 '0's and 8 '1's so 8 * 1.125ms + 8 * 2.25ms == 27 ms. According to this total time required to transmit the frame is 9ms +4.5ms +27ms+27m) = 67.5 ms

Logic Analyser shows the timing details T1 leading pulse at 84.115ms T2 space on 93.28ms T3 Address starts at 97.580ms T4 Address ends , address inverse starts 107.670ms T5 address inverse ends , command starts at 124.486ms T6 Command ends, command inverse starts 135.696ms T7 Command inverse ends and last 562.5µs pulse to show end of transmission.

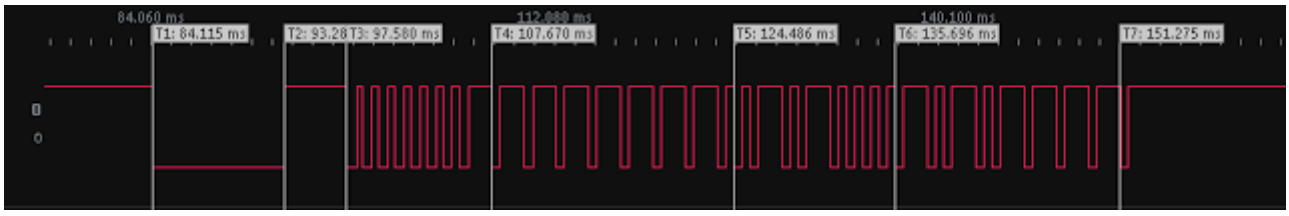


Figure N:

As shown in the schematic and the PCB images this circuit use PIC12F615 as infrared encoder , the IR LED is driven by a separate NPN transistor for longer range and the Coin cell Battery CR2032 is used to power the whole infrared remote. Battery nominal voltage is 3.0V volts but as the datasheet says the PIC12F615 can work down to 2.0V.

The current Consumption of the Circuit in sleep mode is around 35nA which is less then what datasheet claims. The CR2032 coin cell battery will last quite some time.

6.3.1 Datasheets of components

For more detailed technical data datasheets of each detail is introduced.

Microcontroller

- Core: PIC
- RoHS: RoHS Compliant
- Data Bus Width: 8 bit
- Maximum Clock Frequency: 20 MHz
- Program Memory Size: 1.75 kB
- Data RAM Size: 64 B
- On-Chip ADC: Yes
- Operating Supply Voltage: 2 V to 5.5 V
- Maximum Operating Temperature: + 125 C
- Package/Case: PDIP-8
- Mounting Style: Through Hole
- A/D Bit Size: 10 bit
- A/D Channels Available: 4
- Brand: Microchip Technology
- Data ROM Size: 128 B
- Interface Type: RS-232, USB
- Minimum Operating Temperature: - 40 C
- Number of Programmable I/Os: 6
- Number of Timers: 8
- Packaging: Tube

- Processor Series: PIC12
- Program Memory Type: Flash
- Series: PIC12
- Factory Pack Quantity: 60
- Supply Voltage - Max: 5.5 V
- Supply Voltage - Min: 2 V

Mofser

- Manufacturer: Fairchild Semiconductor
- RoHS: RoHS Compliant
- Transistor Polarity: N-Channel
- Drain-Source Breakdown Voltage: 60 V
- Gate-Source Breakdown Voltage: +/- 20 V
- Continuous Drain Current: 0.2 A
- Rds On: 1.2 Ohms
- Configuration: Single
- Maximum Operating Temperature: + 150 C
- Mounting Style: Through Hole
- Package/Case: TO-92
- Packaging: Bulk
- Brand: Fairchild Semiconductor
- Forward Transconductance - Min: 0.1 S
- Minimum Operating Temperature: - 55 C
- Power Dissipation: 0.4 W
- Series: 2N7000
- Factory Pack Quantity: 2000

- Part # Aliases: 2N7000_NL
- Unit Weight: 201 mg

Connectors

First connector:

- Manufacturer: Phoenix Contact
- Product Category: Pluggable Terminal Blocks
- RoHS: RoHS Compliant
- Product: Headers
- Series: MSTBA
- Termination Style: Through Hole
- Number of Positions/Contacts: 3
- Pitch: 5.08 mm
- Current Rating: 12 A
- Voltage Rating: 250 V
- Contact Plating: Tin
- Brand: Phoenix Contact
- Color: Gray
- Flammability Rating: UL 94 V-0
- Housing Material: Polybutylene Terephthalate (PBT)
- Factory Pack Quantity: 50
- Tradename: COMBICON Control
- Type: Wire to Board
- Part # Aliases: MSTBA_2,5/_3-G-5,08 MSTBA253G508
- Unit Weight: 153 g

Second connector:

- Manufacturer: Phoenix Contact
- Product Category: Pluggable Terminal Blocks
- RoHS: RoHS Compliant
- Product: Plugs
- Series: PT
- Termination Style: Screw
- Number of Positions/Contacts: 3
- Wire Gauge Range: 26-14
- Pitch: 5 mm
- Current Rating: 12 A
- Voltage Rating: 250 V
- Mounting Angle: Vertical, Horizontal
- Contact Plating: Tin
- Brand: Phoenix Contact
- Color: Green
- Flammability Rating: UL 94 V-0
- Height: 11.3 mm
- Length: 14.9 mm
- Factory Pack Quantity: 250
- Tradename: COMBICON Compact
- Type: Wire to Wire
- Wire Orientation: Vertical, Horizontal
- Part # Aliases: PT_1,5/_3-PVH-5,0 PT153PVH50
- Unit Weight: 3,390 g

Third connector:

- Manufacturer: Phoenix Contact
- Product Category: Pluggable Terminal Blocks
- RoHS: RoHS Compliant
- Product: Headers - Pin Strip
- Series: PST
- Termination Style: Through Hole
- Number of Positions/Contacts: 3
- Pitch: 3.5 mm
- Current Rating: 8 A
- Voltage Rating: 160 V
- Contact Plating: Tin
- Brand: Phoenix Contact
- Color: Black
- Flammability Rating: UL 94 V-0
- Length: 3.5 mm
- Factory Pack Quantity: 50
- Tradename: COMBICON Compact
- Type: Wire to Board
- Part # Aliases: PST_1,0/_3-3,5 PST10335
- Unit Weight: 340 mg

Transistor

- Manufacturer: Micro Commercial Components (MCC)
- RoHS: RoHS Compliant
- Configuration: Single

- Transistor Polarity: NPN
- Collector- Emitter Voltage VCEO Max: 45 V
- Emitter- Base Voltage VEBO: 6 V
- Gain Bandwidth Product fT: 300 MHz
- Maximum Operating Temperature: + 150 C
- Mounting Style: Through Hole
- Package/Case: TO-92
- Brand: Micro Commercial Components (MCC)
- Continuous Collector Current: 100 mA
- DC Collector/Base Gain hFE Min: 180
- Maximum Power Dissipation: 625 mW
- Minimum Operating Temperature: - 55 C
- Packaging: Ammo
- Series: BC547
- Factory Pack Quantity: 20000

Switch

- Manufacturer: C&K Components
- RoHS: RoHS Compliant
- Operating Force: 1.3 N
- Actuator: Round
- Current Rating: 50 mA
- Voltage Rating DC: 12 V
- Ground Terminal: No
- Contact Form: SPST
- Switch Function: OFF - (ON)

- Mounting Style: Through Hole
- Mounting Direction: Straight
- Stem Height: 4.3 mm
- Color: Black
- Illumination: None
- Packaging: Reel
- Brand: C&K Components
- Contact Plating: Silver
- Operating Temperature Range: - 20 C to + 60 C
- Series: PTS645
- Factory Pack Quantity: 1000
- Termination Style: Solder Pin
- Part # Aliases: Y97HT21A1EAFP

Infra Led

- Manufacturer: Lumex
- Product Category: Standard LEDs - Through Hole
- RoHS: RoHS Compliant
- Illumination Colour: Infrared, Red
- Luminous Intensity: 0.055 mcd
- Wavelength/Colour Temperature: 940 nm, 635 nm
- Viewing Angle: 60 deg
- Forward Current: 20 mA
- Forward Voltage: 1.4 V, 2 V
- LED Size: T-1 3/4
- Packaging: Bulk

- Brand: Lumex
- Lens Dimensions: 5 mm
- Lens Shape: Dome
- Maximum Operating Temperature: + 85 C
- Minimum Operating Temperature: - 40 C
- Mounting Style: Through Hole
- Factory Pack Quantity: 1000

Infrared receivers

- Manufacturer: Vishay
- Carrier Frequency: 38 kHz
- Transmission Distance: 35 m
- Viewing Angle: 45 deg
- Output Current: 5 mA
- Operating Supply Voltage: 4.5 V to 5.5 V
- Supply Current: 1.2 mA
- Maximum Operating Temperature: + 85 C
- Minimum Operating Temperature: - 25 C
- Brand: Vishay

Ultrasonic sensor

- Features:
- 100% Brand New and High Quality
- Working Voltage : 5V(DC)
- Static current: Less than 2mA.
- Output signal: Electric frequency signal, high level 5V, low level 0V.

- Sensor angle: Not more than 15 degrees.
- Detection distance: 2cm-450cm.
- High precision: Up to 0.3cm
- Input trigger signal: 10us TTL impulse
- Echo signal : output TTL PWL signal
- Mode of connection:
- 1.VCC 2.trig(T) 3.echo(R) 4.GND
- Use method: Supply module with 5V, the output will be 5V while obstacle in range,
- or 0V if not.The out pin of this module is used as a switching output
- when anti-theft module, and without the feet when ranging modules.
- Specifications:
- Color: Blue & Silver
- Item size: 44*20*15mm
- Net weight: 11g
- Package weight: 18g

RGB LEDs

- Manufacturer: Kingbright
- Product Category: Standard LEDs - Through Hole
- RoHS: RoHS Compliant
- Illumination Colour: RGB
- Luminous Intensity: 1000 mcd, 1300 mcd, 500 mcd
- Wavelength/Color Temperature: 630 nm, 525 nm, 465 nm
- Viewing Angle: 60 deg
- Forward Current: 20 mA
- Forward Voltage: 2.5 V, 4.1 V, 4 V

- LED Size: T-1 3/4
- Packaging: Bulk
- Brand: Kingbright
- Lens Dimensions: 5 mm
- Lens Shape: Dome
- Maximum Operating Temperature: + 85 C
- Minimum Operating Temperature: - 40 C
- Mounting Style: Through Hole
- Factory Pack Quantity: 500
- Type: Full Color LED Lamps

E27 socket and power supply

- Base type: E27
- Power: 4W
- Input: 100-245 V
- Housing: High Strength Aluminium
- Approvals: CE/RoHS

6.4 Functionalities

Developed LED Lamp has many features, like:

- Fits to universal lamp socket (E27);
- Change colors with remote control (radius 10m);
- Easy construction to change the LEDs;
- Include an automatic brightness control system (maximum radius 4,5m).

Remote control functionalities:

Remote control offers different operating modes and can be configured by the user. There are different colors and options in LED Lamp remote control functions.

Colors: red, orange, yellow, green, blue, cyan, white

Mode Brightness: It is possible to choose the light at your liking. Choose trough the different colour combinations between a colour gammas. There is manually adjustable stepless brightness, creating most favourite ambient light scene.

Mode Static: Manually adjustable fixed colour, creating different ambient light scenes for a different ambient or situations.

Mode Fade out Fade in: It is possible to choose this mode between different colours for increaser and decrease the light, create effect fade.

Mode 7 Colours: Choose this mode between all colours and they are changing automatically, but the transition is like a switch. To change all colous it is possible to make combinations.

Mode 3 Colours smooth transition: The diference between previous mode is that color is changing smootly and mildly.

6.5 Tests and Results

6.6 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

7. Conclusions

7.1 Discussion

Provide here what was achieved (related with the initial objectives) and what is missing (related with the initial objectives) of the project.

7.2 Future Development

Provide here your recommendations for future work.

8. Bibliography

[1] J. P. a. I. Hsu, "LED Lamp Electronics: Past, Present & Future," 2014. [Online]. Available: thttp://www.designnews.com/document.asp?doc_id=271309&. [Accessed March 2014].

[2] DoItYourself Staff, " 5 Common Incandescent Light Bulb Problems," [Online]. Available: http://www.doityourself.com/stry/5-common-incandescent-light-bulb-problems#b. [Accessed March 2014].

[3] M. S. A. S. M. J. Matthew Clyde Wood, "Modular led power system with configurable control interface," 2013. [Online]. Available: http://www.google.com/patents/WO2013081925A1?cl=en. [Accessed March 2014].

[4] J. Bausch, "LED 101: Identifying different types of LEDs," 2011. [Online]. Available: http://www.electronicproducts.com/Optoelectronics/LEDs/LED_101_Identifying_different_types_of_LEDs.aspx. [Accessed March 2014].

[5] A. E. d. Futuro, "Ventajas y Desventajas de la Tecnología LED," 2012. [Online]. Available: http://www.alromar-energia.es/blog/ventajas-y-desventajas-de-la-tecnologia-led/. [Accessed March 2014].

[6] Philips, "TurnRound," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/healthcare/entrance-areas-and-shops/turnround-round/22200/cat/?t1=ProductLis. [Accessed Mmarch 2014].

[7] Philips, "iColor Flex MX – flexible strands of high-intensity, full-color LED nodes," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/architectural-floodlighting/direct-view-lighting/icolor-flex-mx/55044/cat/?t1=ProductList#. [Accessed March 2014].

[8] Philips, "eW Flex SLX – flexible strands of intelligent white-light LED nodes," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/architectural-floodlighting/direct-view-lighting/ew-flex-slx/55043/cat/?t1=ProductList#. [Accessed March 2014].

[9] Philips, "LiColor Tile MX – LED light panel for stunning effects and large-scale video," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/indoor-luminaires/wall-mounted/icolor-tile-mx/55021/cat/?t1=ProductList#. [Accessed March 2014].

[10] Philips, "AmazonLED² – reliable beauty," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/fashion-stores/selling-floor/amazonled2/65069/cat/?t1=ProductList#. [Accessed March 2014].

[11] Philips, "ArchiPoint iColor," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/entertainment/touring-stage/archipoint-icolor/66139/cat/?t1=ProductList#. [Accessed March 2014].

[12] Philips, "Marker LED – eye-catching," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/architectural-floodlighting/markers-inground-and-underwater/marker-led/22279/cat/?t1=ProductList#. [Accessed March 2014].

[13] Philips, " BBS500 LedUplight," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/architectural-floodlighting/markers-inground-and-underwater/leduplight-bbs500/21790/cat/?t1=ProductList#. [Accessed March 2014].

[14] Philips, "BBS430 LedStep rectangular," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/architectural-floodlighting/markers-inground-and-underwater/ledstep-rectangular-bbs430/21789/cat/?t1=ProductList#. [Accessed March 2014].

[15] Philips, " StraightLine – in line with the street," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/road-and-urban-lighting/road-and-urban-luminaires/straightline/55042/cat/?t1=ProductList#. [Accessed March 2014].

[16] Philips, "Milewide – pure and contemporary," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/road-and-urban-lighting/road-and-urban-luminaires/milewide-led/milewide-led-mini/22417/cat/?t1=ProductList#. [Accessed March 2014].

[17] Philips, "CitySpirit Street – reveal the spirit of your City," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/cityspirit-led/cityspirit-street-led/22409/cat/. [Accessed March 2014].

[18] Philips, "SecuriPack – fit the light for life," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/sports-and-area-floodlighting/security-lighting/securipack-bcs200/22475/cat/?t1=ProductList#. [Accessed March 2014].

[19] Philips, "Stela - revolutionary success on your doorstep," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/road-and-urban-lighting/road-and-urban-luminaires/stela/stela-long-square-wide/71522/cat/?t1=ProductList. [Accessed March 2014].

[20] Philips, "DayZone – innovative design meets sustainability," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/indoor-luminaires/recessed/dayzone/21947/cat/. [Accessed March 2014].

[21] Philips, "GentleSpace – taking high-bay lighting to the next level," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/indoor-luminaires/high-bay-and-low-bay/high-bay/gentlespace/58188/cat/. [Accessed March 2014].

[22] Amazon, "HDE® Remote Control Color Changing 16 LED Light Bulb with RC," 2014. [Online]. Available: http://www.amazon.com/Remote-Control-Color-Changing-Light/dp/B009UZD81Y/ref=sr_1_20?s=lamps-light&ie=UTF8&qid=1394131590&sr=1-20. [Accessed March 2014].

[23] Philips, "LivingColors Bloom White," 2014. [Online]. Available: http://www.usa.philips.com/c-p/709976048/livingcolors. [Accessed March 2014].

[24] Alibaba, "Camera led flash module," 2014. [Online]. Available: http://www.alibaba.com/product-detail/camera-led-flash-module_660627298.html. [Accessed March 2014].

[25] TorchDirect, "LED Lenser P5.2 - 140 Lumen," 2014. [Online]. Available: http://www.torchdirect.co.uk/professional-torches/led-lenser-p52-140-lumen.html. [Accessed March 2014].

[26] Amazon, "LEMONBEST 16.4FT SMD 5050 Water-resistant 300LEDs RGB Flexible LED Strip Light Lamp Kit + 44 Key IR Remote Controller," 2014. [Online]. Available: http://www.amazon.com/LEMONBEST-SMD-Water-resistant-Strip-Controller/dp/B00AJJDLHQ. [Accessed March 2014].

[27] Amazon, "Romantic Bright Automatic 7 Color LED Shower Head Facut Home Bathroom Water Glow," 2014. [Online]. Available:

http://www.amazon.com/Romantic-Bright-Automatic-Shower-Bathroom/dp/B00ASLSHX8/ref=sr_1_46?s=lamps-light&ie=UTF8&qid=1394131985&sr=1-46. [Accessed March 2014].

[28] Philips, "eW Profile Powercore – Under-cabinet white light LED fixture with an ultra low profile," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/indoor-luminaires/battens/ew-profile-powercore/58461/cat/?t1=ProductList. [Accessed March 2014].

[29] Philips, "ColorFuse Powercore," 2014. [Online]. Available: http://www.colorkinetics.com/ls/rgb/colorfuse/. [Accessed March 2014].

[30] Philips, "DecoScene LED BBP521," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/outdoor-lighting/architectural-floodlighting/floodlighting/decoscene-led/decoscene-led-bbp521/910403780212_eu/. [Accessed March 2014].

[31] Philips, "ColorBurst 6," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/entertainment/architainment/colorburst-6/55029/cat/?t1=ProductList. [Accessed March 2014].

[32] Philips, "ColorBlast Powercore," 2014. [Online]. Available: http://www.colorkinetics.com/ls/rgb/colorblast12pc/. [Accessed March 2014].

[33] Philips, "ColorReach Powercore gen2," 2014. [Online]. Available: http://www.colorkinetics.com/ls/rgb/colorreach/. [Accessed March 2014].

[34] Philips, "eW Graze MX Powercore," 2014. [Online]. Available: http://www.colorkinetics.com/ls/essentialwhite/ewgrazemxpowercore/. [Accessed March 2014].

[35] Philips, "LEDline² – composing with ligh," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/led/wall-washing-grazing/ledline2-bbs713-716/21791/cat/. [Accessed March 2014].

[36] Philips, "Maxos LED Industry – innovative, flexible solution delivers ideal light output," 2014. [Online]. Available: http://www.ecat.lighting.philips.com/l/maxos-led/63400/cat/. [Accessed March 2014].

[37] Philips, "C-Splash 2," 2014. [Online]. Available: http://www.colorkinetics.com/ls/rgb/csplash2/. [Accessed March 2014].

[38] Onled, "X3B Freezer Light," 2014. [Online]. Available: http://www.onnled.net/productdetails.aspx?pid=329. [Accessed March 2014].

[39] Onnled, "X5 Freezer Light new," 2014. [Online]. Available: http://www.onnled.net/productdetails.aspx?pid=333. [Accessed March 2014].

[40] Osram, "LUMOS LED," 2014. [Online]. Available: http://www.osram.co.uk/osram_uk/products/luminaires/indoor-luminaires/luminaires-for-retail-displays/luminaires-for-cold-store-shelves/lumos-led/shelf-luminaire,-light-color-5000-k/led442760/index.jsp?productId=ZMP_1077768. [Accessed March 2014].

[41] Philips, "LED A Shape," 2014. [Online]. Available: http://www.usa.philips.com/c-p/046677425265/led-11w-60w-medium-base-e26-daylight-dimmable. [Accessed March 2014].

[42] Philips, "Reflector - Flood," 2014. [Online]. Available: http://www.usa.philips.com/c-p/046677429409/led-13w-75w-medium-base-e26-bright-white. [Accessed March 2014].

[43] Mobile World, "Bluetooth technology is not a suitable Wi-Fi replacement,IR, WiFi

and Bluetooth Remote Control for your PC," 2011. [Online]. Available: http://mobileworldz.blogspot.pt/2011/05/bluetooth-technology-is-not-suitable-wi.html. [Accessed March 2014].

[44] Wikipedia, "Wi-Fi," [Online]. Available: http://en.wikipedia.org/wiki/WIFI. [Accessed March 2014].

[45] Google play, "WiFi Remote Control," 2013. [Online]. Available: https://play.google.com/store/apps/details?id=power.wifi.controller. [Accessed March 2014].

[46] AppLamp, "Wifi Box with APP for AppLamp lighting," [Online]. Available: http://www.wifiledlamp.com/applamp-wifi-box-with-app-for-applamp-lighting.html. [Accessed March 2014].

[47] AppLamp, "Wifi Box with APP for AppLamp lighting," [Online]. Available: http://www.wifiledlamp.com/applamp-wifi-box-with-app-for-applamp-lighting.html. [Accessed March 2014].

[48] Lomedo, "The LUMEDO iPhone LED Controller," [Online]. Available: http://www.lumedo.com/. [Accessed March 2014].

[49] Lumedo, "iPhone LED Controller," [Online]. Available: http://www.lumedo.com/product/. [Accessed March 2014].

[50] Wikipedia, "IR remote control," [Online]. Available: http://en.wikipedia.org/wiki/Remote_control#Other_remote_controls. [Accessed March 2014].

[51] eBay, "IR Remote Control," [Online]. Available: http://www.ebay.com/itm/24-Key-IR-Remote-Control-16-Colors-Changing-5050-3528-SMD-RGB-LED-Strip-Colors/111295784297?_trksid=p2047675.c100009.m1982&_trkparms=aid%3D333001%26algo%3DRIC.FIT%26ao%3D1%26asc%3D20466%26meid%3D5369348230301477310%26pid%3D100009%2. [Accessed March 2014].

[52] Kramer Eelectronics, "RC Configuration and," [Online]. Available: http://www.kramerelectronics.com/downloads/manuals/rc_configuration_and_installation_guide.pdf. [Accessed March 2014].

[53] Wikipedia, " Ultrasonic sensor," 2014. [Online]. Available: http://en.wikipedia.org/wiki/Ultrasonic_sensor. [Accessed March 2014].

[54] IFM, "Laser sensor," [Online]. Available: http://www.ifm.com/ifmaus/web/pinfo010_070_040.htm. [Accessed March 2014].

[55] M. Thoras, "Global LED Lighting Market 2012-2016: Industry Analysis, Size, Shares, Growth, Trends, and Forecast Research Report," 2014. [Online]. Available: http://www.prweb.com/releases/2014/02/prweb11564707.htm. [Accessed March 2014].

[56] Strategies Unlimited, "The Worldwide Market for LEDs: Market Analysis and Forecast 2014," 2014. [Online]. Available: http://www.strategies-u.com/articles/reports/the-worldwide-market-for-leds-market-analysis-and-forecast-2014.html. [Accessed March 2014].

[57] Wikipedia, "Green politics," [Online]. Available: http://en.wikipedia.org/wiki/Green_politics. [Accessed March 2014].

[58] European Commission, "Energy Efficiency," 2011. [Online]. Available: http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm. [Accessed March 2014].

[59] Naturan Resources Canada, "Canadian Industry Program for Energy Conservation

(CIPEC)," 2014. [Online]. Available: http://www.nrcan.gc.ca/energy/efficiency/industry/cipec/5153. [Accessed March 2014].

[60] Inter- America Developement Bank, "Energy Efficiency," [Online]. Available: http://www.iadb.org/en/topics/energy/energy-efficiency,2654.html. [Accessed March 2014].

[61] Relience, "China outlines ten programs for energy efficiency," 2004. [Online]. Available: http://www.resilience.org/stories/2004-12-09/china-outlines-ten-programs-energy-efficiency. [Accessed March 2014].

[62] LEDLuxor, "Top 10 Benefits of Using LED Lighting," 2012. [Online]. Available: http://www.ledluxor.com/top-10-benefits-of-led-lighting. [Accessed March 2014].

[63] J. Murray, "All the Taxes Your Business Must Pay," [Online]. Available: http://biztaxlaw.about.com/od/typesofbusinesstaxes/tp/allbiztaxes.htm. [Accessed March 2014].

[64] J. Kuo, "2014 LED Market Demand And Supply," 2014. [Online]. Available: http://www.ledinside.com/download/output/2014_LED_Market_Demand_and_Supply.pdf&sn=0. [Accessed March 2014].

[65] BSD Global, "Business and Sustainable Development," [Online]. Available: http://www.iisd.org/business/. [Accessed March 2014].

[66] Financial Times Lexicon, "Definition of business sustainability," [Online]. Available: http://lexicon.ft.com/term?term=business-sustainability. [Accessed March 2014].

[67] RoHS, "RoHS Compliance Definition," [Online]. Available: http://www.rohscompliancedefinition.com/. [Accessed March 2014].

[68] Business Dictionary, "Social sustainability," [Online]. Available: http://www.businessdictionary.com/definition/social-sustainability.html#ixzz2xxR9bdv8. [Accessed March 2014].

[69] Integrated Network for Social Sustainability, "What is social sustainability?," [Online]. Available: http://clas-pages.uncc.edu/inss/what-is-social-sustainability/. [Accessed March 2014].

[70] ISSP, "Confused about social sustainability?," [Online]. Available: http://www.sustainabilityprofessionals.org/system/files/Confused%20about%20social%20sustainability_0.pdf. [Accessed March 2014].

[71] R. Bakshi, "Gross National Happiness," 2005. [Online]. Available: http://www.alternet.org/story/21083/gross_national_happiness. [Accessed March 2014].

[72] [Online]. Available: http://www.compasscareer.com/wp-content/uploads/Business-Ethics.jpg. [Accessed April 2014].

[73] PACE, "ETHICAL BEHAVIOR IS GOOD BUSINESS," [Online]. Available: http://www.entre-ed.org/_teach/ethics.htm. [Accessed March 2014].

[74] National Society of Professional Eengineers, "What is engineering ethics?," [Online]. Available: http://www.nspe.org/resources/ethics/ethics-resources/faq#whatis. [Accessed March 2014].

[75] [Online]. Available: http://media.tumblr.com/tumblr_lsuke1qcQo1qd9o7r.png. [Accessed April 2014].

[76] IEEE, "IEEE Code of Ethics," [Online]. Available:

http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed March 2014].

[77] "qgito.net," [Online]. Available: http://qgito.net/wp-content/uploads/2012/08/etyka-w-biznesie-300x201.jpg. [Accessed April 2014].

[78] Pine Manor College, "Academic Ethics and Integrity," [Online]. Available: http://www.pmc.edu/academic-ethics-and-integrity. [Accessed March 2014].

[79] "LANL," [Online]. Available: http://www.lanl.gov/projects/envplan/images/logo_sm2.png. [Accessed April 2014].

[80] EPA, "Environmental Stewardship," [Online]. Available: http://www.epa.gov/stewardship/. [Accessed March 2014].

[81] Ethical Consumer, "Shopping guide to energy saving light bulbs," [Online]. Available: http://www.ethicalconsumer.org/buyersguides/energy/lowenergylightbulbs.aspx. [Accessed March 2014].

[82] European Commission, "CE marking - Basics and FAQs," [Online]. Available: http://ec.europa.eu/enterprise/policies/single-market-goods/cemarking/about-ce-marking/index_en.htm. [Accessed March 2014].

[83] PCB, "Printed Circuit Board Editor," [Online]. Available: http://pcb.geda-project.org/. [Accessed March 2014].

[84] G. Chaudhary, "NEC Protocol IR (Infrared) Remote Control With a Microcontroller," 2013. [Online]. Available: http://www.circuitvalley.com/2013/09/nec-protocol-ir-infrared-remote-control.html. [Accessed March 2014].