Project Kungsholms strand

ADVANCED INDIVIDUAL CONTROL OF OUTDOOR LIGHTING

Official Final Report - Kungsholms strand project

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ABSTRACT

Sustainability versus human perception is one of the trending topics in the field of lighting design. Considering the current scenario, opting for sustainable solutions is no longer a choice, but the need of the hour. In spite of the necessity to go for sustainable solutions, there is always an ambiguity regarding the response of the people towards it. The motive behind this project was to experiment with sustainable, energy efficient lighting solutions by using lighting controls and discover if it works well with the people, providing the scope for implementation in the long run. This involved analysis of the influence of lighting control over users in an urban environment, thereby developing guidelines for the utilization of lighting control systems in the best possible way. The focus of the study was based on evaluation of test scenarios for a stretch of temporary street lighting installation with lighting controls and obtaining the feedback from user experience in terms of human perception, safety and comfortability. The objective was to determine how to control urban lighting with comprehensive lighting strategies and derive results leading to the proposals, possibly multiple, for the lighting control strategy. Energy use formed an integral part of the results derived.

The evaluation indicated that people responded positively towards the use of lighting controls in an urban environment and were satisfied in terms of human comfortability, perception and safety. Also, by the usage of lighting controls, the energy savings vary within a range of approximately 18% to 42% when compared with the stable LED lighting solution without using lighting controls.

PROJECT INTRODUCTION

KUNGSHOLMS STRAND - Advanced individual control of outdoor lighting

2.1 PROJECT BRIEF

The project was proposed at the Energy Agency and aimed to develop ways towards energy-efficient lighting.

With changing times and the world moving towards sustainable and energy-efficient solutions, it is important to take some initiatives in the direction of energy-efficient technology. Energy-efficient light sources such as LED in combination with advanced technology are expected to reduce the electrical consumption to half as compared to the conventional solutions. With this test installation and its results, the project can inspire other municipalities and certainly can speed up their work to switch to energy efficient lighting, hence creating better sustainable environments for people.

As a part of this proposal, technology for advanced control of outdoor lighting was intended to be tested and evaluated along a pedestrian and bicycle path in Stockholm (Kungsholms strand). The experimental site was chosen along a stretch of 750 metres constituting of a total of 34 street light poles housed with new LED fixtures and were installed with modern lighting control systems. Technical assessment (energy savings, reliability etc.) was aimed to be related as to how users perceive visual quality, safety and security in the space with these lights.

The idea was to develop different management and control strategies for individual lighting control (per fixture), test and evaluate them. For example, one of the strategies was to use presence control system with comparatively reduced levels of illumination in absence of people/traffic. The project is carried out in collaboration with Municipality of Stockholm city- Stockholms Stad (property owner), Fagerhult (lighting solutions), Tritech (control technology specialist), Sustainable Innovation – Sust (project management team) and the Lighting Laboratory from Kungliga Tekniska högskolan- KTH University.

2.2 PROJECT PARTNERS

I. Fagerhult

A Sweden based company, and is one of the leading lighting groups across Europe. They deal with creating modern products and exciting, energy-efficient, environmentally-adapted lighting installations, successfully integrated into their individual environments.

Role:

- Lighting expertise

- Developing products / solutions as per the project requirements.

- Delivering products / solutions on time.

II. Tritech

Tritech is involved in the development, management and production of industrial products in the field of M2M (machine to machine).

Role:

- Development and adaptation of the control system for individual control and presence control.

- Operation and support of control systems during the project period.

III. Stockholm stad and Trafikkontoret

The Municipality of Stockholm deals with the city development and refurbishing.

Role:

- Construction owners and specifying requirements for lighting solution.

- Responsible for the current installation supervision.

- Concerned organisation in dealing with the public.

IV. Sust (Sustainable Innovation)

Sust is founded by leading companies in collaboration with the Swedish Energy Agency. Sust deals with sustainable energy solutions with leading companies, entrepreneurs and researchers aiming for direct results, environmental benefits, cost savings and energy efficiency.

Role:

- Project management and coordination of project

- Research expertise and research contacts

- Administration of grants from the Energy authorities

- Evaluation (planning, implementation and reporting)

- Common external communication about the project.

2.3 PROJECT GOALS

The project was proposed at the Energy Agency and aimed to develop ways towards energy-efficient lighting. As a part of this, the proposal involved the idea of controlling LED luminaires with lighting control systems in an urban environment as an experimental test installation. The project goals can be defined in the following points:

- A presence control system in combination with LED makes it possible to reduce energy consumption considerably by control of lighting levels. While there is a risk that controlling the environment in itself defeats the purpose of creating a secure and transparent environment, project will examine how governance should be designed so as not to jeopardize the safety of users comfort.

- Technology assessment (energy savings, reliability, etc.) will be related to how users perceive visual quality, safety and security.

- For the pilot project involving lighting control, the idea is to provide a saving potential between 40-60% of energy use, compared with the old traditional system (high- pressure sodium lamps). By installing an intelligent lighting control that reduces lighting levels at night, is estimated to reduce more than 30% for the remaining energy. All of this is aimed without compromising on the road users' perceived comfort. Such comparative analysis is carried out via interviews with the users in the space.

- The evaluation/outcome of the project will be used as a basis for opting among sustainable options for energy efficiency.

- The evaluation will lead to strategies (possibly multiple) for illumination of the path that meets the balanced energy-efficiency, economy and comfort of road users (security, safety, visual quality). This would be done in two parts – by *technical evaluation* in terms of comparisons of energy consumption calculations and *visual evaluation* – by interviews from the people and processing their responses regarding vision, safety and security in the environment.

SITE ANALYSIS

KUNGSHOLMS STRAND, STOCKHOLM

Studying the site of the installation provides a better understanding of the site context.

The following points would be discussed in the site analysis:

1. LOCATION
2. SURROUNDINGS
3. GENERAL ATMOSPHERE AND VANTAGE POINTS (VIEWS)
4. USERS
5. ACCESS POINTS TO THE SITE
6. MOVEMENT
7. PEAK HOURS/ TRAFFIC

(Fig. 1.1) Photograph taken from the site overlooking the other side of Kungsholms strand

KUNGSHOLMS STRAND AREA

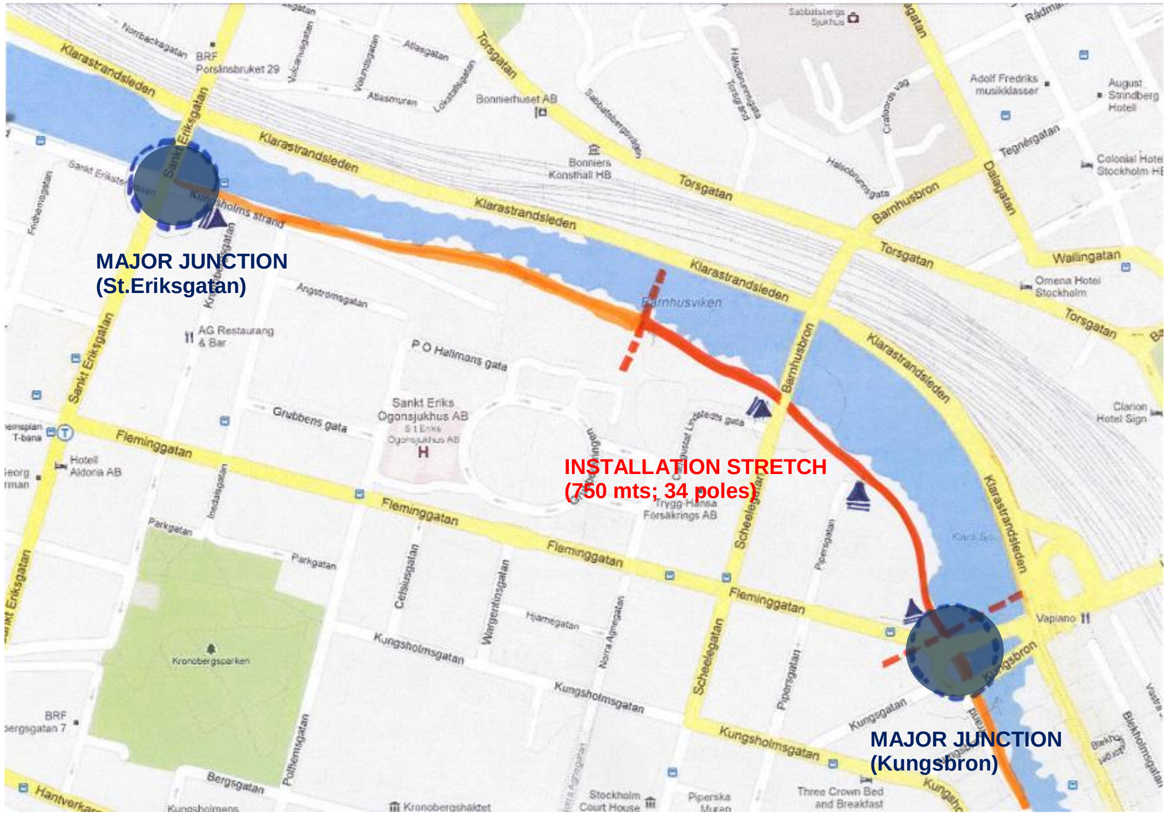
SITE STRETCH

(Fig. 1.2) Kungsholms strand, Google satellite map

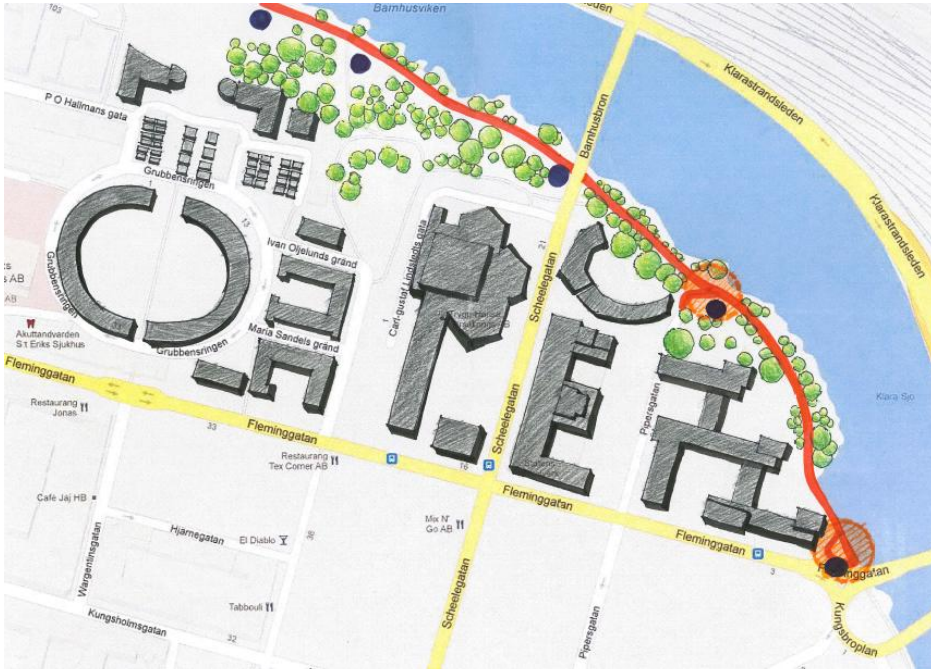
1. LOCATION

The site is located at Kungsholms strand, Stockholm. Kungsholms strand is a street in the district of Kungsholmen in Stockholm. It stretches till Kungsholmen on the northern side, along Barnhus Bay and Karlberg Sea.

Stockholm Central is at a very close proximity to the site, and the installation stretch is in the central area of Stockholm. The site under analysis is a pathway along the water side for pedestrians and bicyclists. The length is marked with bold red colour in the (Fig 3.7) and (Fig 3.8). The major junctions are the intersections on the main road of St.Eriksgatan and that on the Kungsbronplan main road. The junctions are marked on the adjacent map with blue colour in the (Fig 3.8).



(Fig. 1.3) Kungsholms strand, Google map



(Fig. 1.4) Kungsholms strand with site features

BUILDINGS

TREES AND VEGETATION

NODES

ACCESS POINTS

INSTALLATION SITE

MAIN ROADS

2. SURROUNDINGS

The test lighting installation is along the water side, lined with thicker vegetation (trees) on one side (Fig 3.9) as compared to the other side. The side which has the bank of the water stream has lesser trees and small shrubs. The pathway accommodates benches at regular intervals along the whole length for people to sit by the waterside and relax(Fig.4.0) There are a few buildings around the site stretch, consisting of residential and commercial nature. Over head bridges for motor vehicles and pedestrians

(Fig. 1.5) Photograph showing the installation site

are built over the stream (Kungsholms strand) indicating the roads can be seen at a higher level with respect to the installation pathway.

3. GENERAL ATMOSPHERE AND VANTAGE POINTS (VIEWS)

The atmosphere has a good ambience, with view of the water body and city elements on the other side of the bank. The pathway is very busy usually on working days and comparatively has lesser traffic on weekends.

4. USERS

Pedestrians and bicyclists are the broadly classified categories when based on the frequent type of users on the road. Otherwise, considering various activities, the users of the space are pedestrians, walkers, joggers, dog-walkers, bicyclists and parents with their babies in the prams. Mostly, the pathway is used as a link between the users' source and destination places. Mostly, the purpose of taking the route is:

a. Commute to/from work

b. Exercise in the form of jogging, brisk walking, taking the dog for a walk

c. Casual strolls, recreation and relaxation.

5. ACCESS POINTS and JUNCTIONS

The various access points and junctions are marked in the (Fig 3.9) indicating the number of points how people can approach the place.

6. MOVEMENT

The movement along the side is considered mostly linear, with clearly distinguished tracks for pedestrians and bicyclists. There is just one Y-junction along the installation, allowing people to divert their movement from the installation stretch when required.

7. PEAK HOURS OF TRAFFIC

The hours for the traffic observation are considered from the time of the lighting installation being turned on. Based on the observations at the site, the traffic is heavy from 18.00- 21.00, although it is comparatively much lesser on weekends. Friday evenings and nights were busier among the rest of the week. The traffic gradually reduces after 21.00 till midnight and is sparse after midnight.

8. GENERAL OBSERVATION IN TERMS OF LIGHTING

Apart from the light from the lighting installation, the other sources or lighting elements on the site were:

- Light reflections from the water body (Fig. 4.1)
- Light impression from the presence/absence of dense vegetation and tree foliage
- City lights visible on the other side of the water body (Kungsholms strand) (Fig.4.1)
- Light from the public lighting from the overhead road, bridges, on the wall under the bridge (Fig. 4.2)
- Light from the surrounding buildings.

(Fig. 1.6) Photograph showing reflections of light in the water and city lights on the other side of the waters of Kungsholms strand

(Fig. 1.7) Photograph showing the lights washing the walls under the bridge

TECHNICAL INFORMATION FOR INSTALLATION

● GENERAL INFORMATION

In the (Fig. 1.4), the green dots broadly represent the installation poles with new LED light fixtures. A total number of 34 poles were installed with the new fixtures over a stretch of 750 metres.

(Fig. 1.8) Kungsholms strand installation with new LED light fixtures

● NEW LUMINAIRE

INFORMATION

NAME: Azur LED

LED 2000 lm

FEATURES: Luminaire with LED and DALI communication

(Fig. 1.9) Installed new LED light fixture from Fagerhult

● SENSOR FOR PRESENCE AND MOTION DETECTION

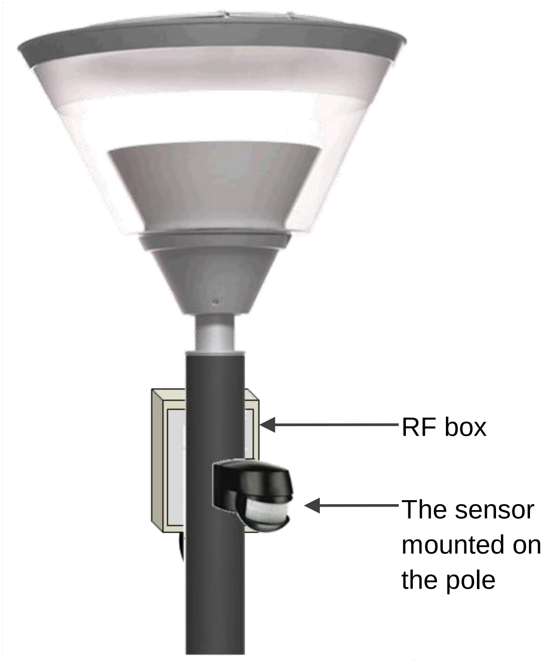
E13 031 15

• Motion detector with 200 ° coverage angle for convenient switching on the lights
• Prevents incorrect operation because of to the built-in switch
•Test function / automatic operation
• Convenient plug connection for quick and easy assembly
• Double membrane gland for cables
• Connection terminal with large terminal compartment and the cable entry at the top, underneath or on the back
• Quick-connect terminals for the connection of protective conductors included
• Adaptation of the detection zone and range with the rotary and flexible ball and socket technology
• Protective cover with bayonet mount for positioning elements. Prevents accidental parameter settings and protects against the elements
• Wall mounted
• Special socket for mounting in the interior, respectively. outside corners are available as an accessory

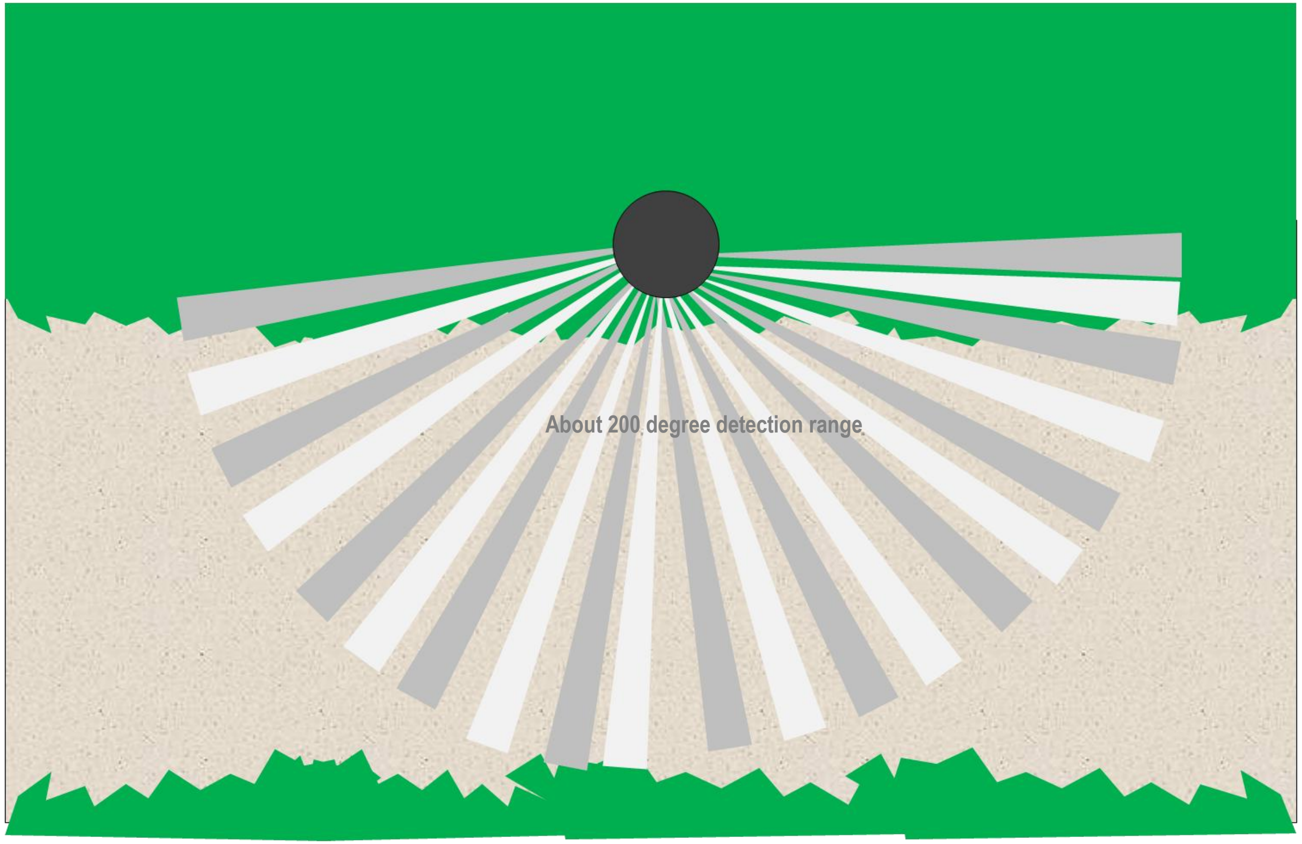
Technical data
Voltage: 230V ~ 50Hz
Coverage angle: 200 °, the sensor horizontally rotatable ± 90 °
Range: about 12 m at an installation height of 2.5 m
Range Adjustment: Mechanically through bending of the ball, max 80 °
Adjustments: Mechanically by setting controller
Switching capacity: 230 V ~ 50 Hz
Time setting: Approximately 4 sec. - 10 min.
Brightness: Approximately 2 to 1000 lux
Permissible ambient temperature: -25 ° C... +55 ° C
Protection: IP44 Protection class: II
Control Brand: TÜV Süd
Installation: Wall mounting.
Material in housing: UV stabilized polycarbonate

(Fig. 2.0) E13 031 15

(Fig. 2.1) E13 032 03

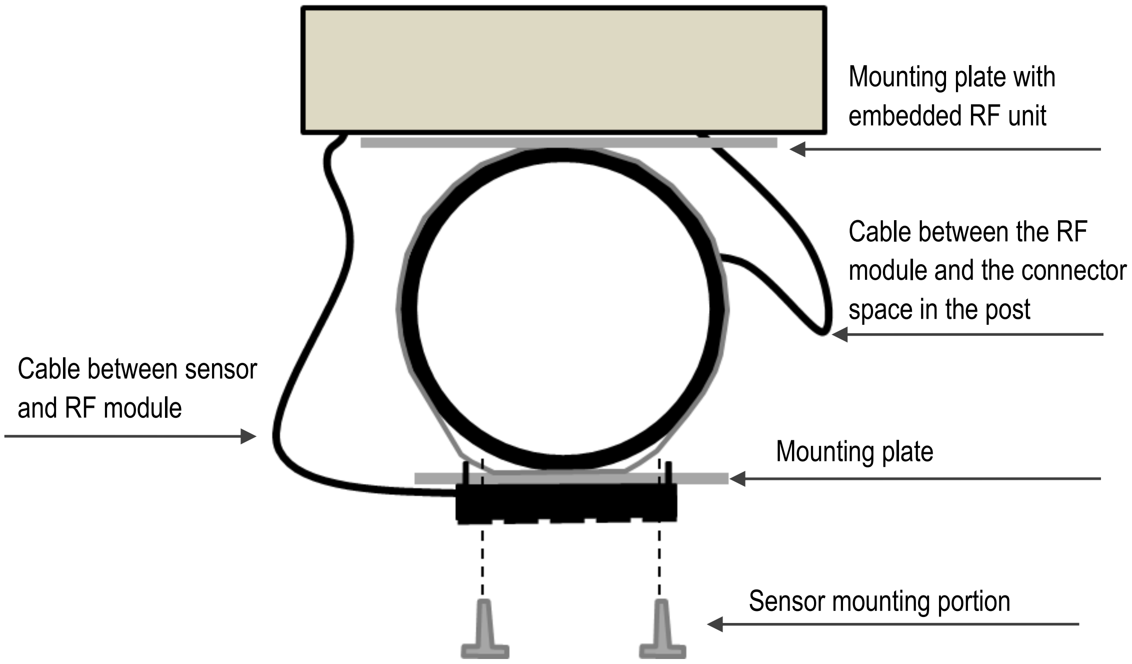


(Fig. 2.2) Control equipment and sensor positioned on the pole



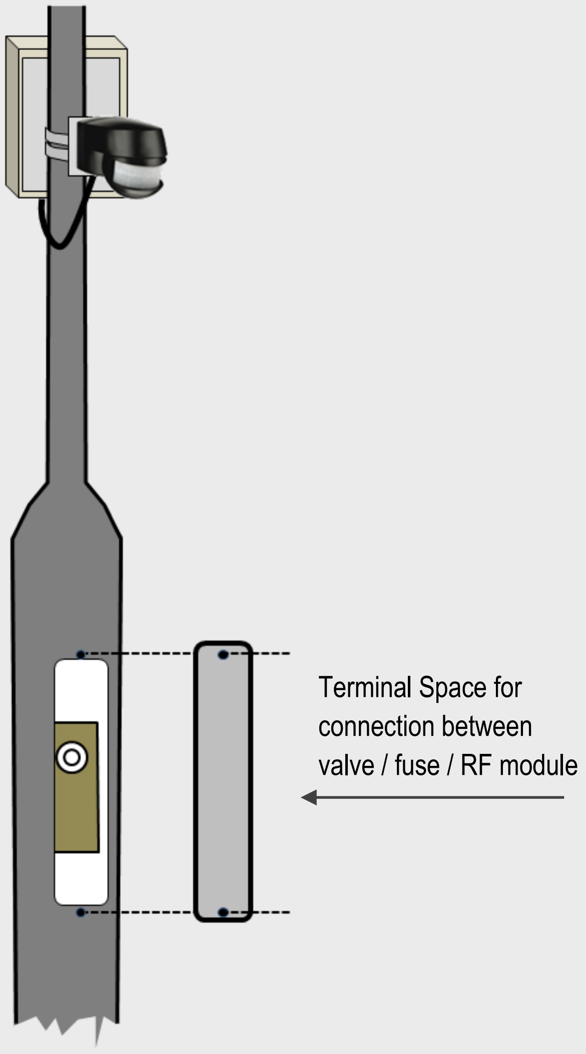
(Fig. 2.3) Illustration depicting the range of the sensor

- INSTALLATION DETAILS



(Fig. 2.4) Illustration showing the installation details

- SENSOR AND RF DEVICE PLACED ON POLE



(Fig. 2.5) Illustration showing sensor and RF device placement on pole

FUNCTIONALITY OF THE SYSTEM

LIGHT POLES – COMPONENTS and HOW DOES IT WORK?

Each lightning pole contains the following equipment:

1. A luminaire – using LED as light source which has a maximum power of *24W*.

(Fig. 2.6) LED source

2. A DALI controller – used to set different brightness of the luminaire.

3. A movement detector – (PIR) detects people. Actually it detects objects that are warmer than the surroundings and that moves.

(Fig. 2.7) Movement detector module

4. A controller – the unit that controls the lightning power. The controller is a Meshnet radio unit from Tritech. That unit consist of the following parts:

(Fig. 2.8) Controller and its parts

- A DALI master – that can communicate with the DALI controller close to the luminaire and order different brightness of the luminaire.
- A short distance radio – used to communicate with other luminaire poles and with a master node. Each radio node has an identity (serial number) so that it can be addressed. The radio uses 869 MHz.
- Control logic – that controls the installation.

Working : The functionality of the system is rather simple. During the night, each pole normally uses low power lighting. This not only saves energy but also gives a less lit - up surrounding. If a pole detects presence of a person (from the movement detector), it lights itself up and also sends out a radio message to a specified number of surrounding poles. Each pole listens for such a radio message, and when it receives a radio message containing its ID, then the pole changes to a higher intensity of light (higher power). The pole stays in this higher power state for a pre-set time interval, after which it reverts back to its low power state.

CONFIGURATION

The system has a number of configurations that controls the behaviour of the system.

High intensity power level – In this system a scale of 0-10 is used. 0 means no power (off) and 10 is full power. These levels are converted into levels used by DALI (0-255) using the following conversion table:

Level	***DALI level***
0	0
1	170
2	195
3	210
4	221
5	229
6	235
7	241
8	246
9	250
10	254

(Fig. 2.9) Table showing the DALI conversion table

High intensity power level - The choice of high level to use can be set and changed individually for each pole and also individually for each hour of the day. This means that if a system normally uses level 10 (highest possible level) at presence during the evening, a different and lower level (like 8) can be used at non peak hours, like between 0 – 4 in the morning. This is one of the ideas to save even more energy.

Low intensity power level – a level of 0-10. Can be used in the same way as high intensity power level.

Time with high power level – time (in seconds) that high power should remain if there is no new presence detection.

Which neighbor poles to light up – a list of neighboring pole identities to be sent out in the radio message at presence indication to light up neighbouring poles. Note that this list is different for each pole because each pole has different neighbours.

EXAMPLE OF THE SCENARIO CONDITION

Assume the following set-up and example to visualize the functionality of the system.

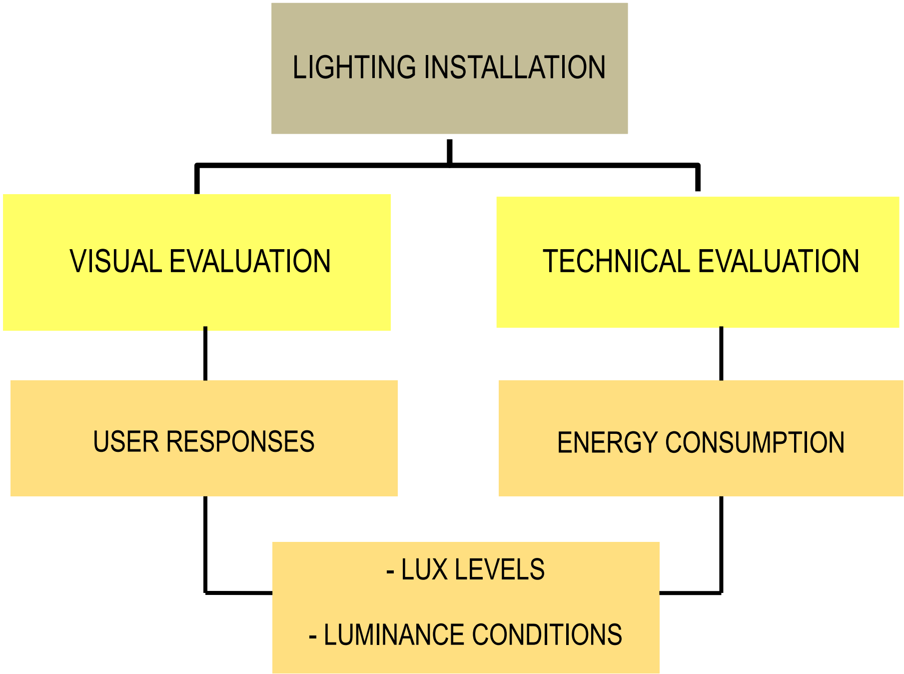
(Fig. 3.0) Graphic describing example of a scenario situation

- Numbers in the picture indicate the addresses of each lightning pole.
- A person is moving close to pole 3. The PIR activates and sends a message to the control unit.
- The control unit sends a radio message saying: “Please light up pole #2, #3, and #4” (itself and the closest neighbours).
- This radio message is received by all poles (#1 - #8). Pole #1 and #5 - #8 finds that message is not for them and does nothing.

- Pole #2 - #4 finds that message is for them and lights up the pole for a preset amount of time (typically from 60 or 120 seconds). Note that pole #3, the one transmitting the message, also receives its own transmission and reacts to it.
- Each pole that detects the radio message will re-transmit it again – but only once. This extends the radio range area.
- If the person moves closer to pole #2 – it will do a similar transmission saying “Please light up pole #1, #2 (own), and #3”.
- After a certain amount of time, the pole will return to low power again. This timer is restarted every time the pole receives a radio message to light up to high power.

PROJECT EVALUATION

Since the start, the aim of the project has been to go for energy-efficient solutions but without jeopardising on the road user comfort. In order to study both the aspects, the evaluation methodology was carefully devised after thorough discussion. As user comfortability and energy issues, both formed the integral part of the project, both these aspects could be classified into the following categories:



(Fig. 3.1) Evaluation process

5.1 VISUAL EVALUATION

5.1.a. USER RESPONSES - QUESTIONNAIRE RESULTS EVALUATION

A questionnaire was formulated in order to gather responses from people and the results from the questionnaire were obtained by questioning the people using the Kungsholms strand pathway. The results will be analysed in the pie chart, bar graph format and will be expressed in percentage values. In total, 105 people were questioned, 41 female and 64 male. Both men and women were equally willing to participate, though the percentage of men using the stretch was comparatively high. The pathway was actively used during the stipulated time of the survey (20.30hrs- 23.30 hrs), though the traffic does vary from working days to weekends; high to low respectively. It is mostly used for jogging, brisk- walking, pedestrians, taking the dog for a walk, bicycling and casual strolls, when ranked by the order of priority. It was not very difficult to get the people to participate during the initial weeks, but later during the last 3 weeks of the interviews, it was difficult to approach people and ask them to participate in the survey. This sudden drop in the participation from the people was possibly subjected to the change in weather conditions. Also, during the survey over 5 weeks, the most challenging thing was to stop the joggers and ask them to participate. The age group of 20-40 and 40-60 were the ones positively willing to help with the survey. Some of them did have some useful insights when discussed about lighting.

Before starting with the interviews with the public, a test group of 10-12 people visited the site for preliminary discussion in order to discuss the choice of lowest light level for the installation. The test group comprises of Lighting engineers and specialists dealing with accessibility in public areas, both from the municipality of Stockholm and also the people belonging to the project group. The light levels for the light poles can vary within a range of level 1 to level 10. The lowest light level was chosen as level 5 based on the visual judgement by the test group.

NOTE: In the following cases from now on, **'Level 10'** means 100% light output of the luminaire with lux level of 100 lux.

'Level 5' means 50% of the light output of the luminaire with lux value of 54 lux.

'Level 8' means 80% of the light output of the luminaire with lux value of 82 lux.

In LOW POWER LEVEL column: (7 for first 3) indicates 3 end poles from either side of the installation are always on low power level of 'level – 7' and not on 'level -5; unlike the rest of the poles. The end poles (at the entering points of the installation) were kept on level – 7 and not on level – 5 to maintain higher brightness levels while approaching the place, making it more inviting for the user and make him/her feel safe while entering into the space.

Five scenarios were designed to be implemented over a period of 5 weeks. The idea behind the formulation of scenarios was to test the extent of the possibilities with lighting control systems; ranging from the most basic scenario (with no presence control system and maximum power level of 10) to the extreme scenario with lighting control and short timer settings- both with maximum power level of 10 and lower power levels of 8.The aim was to test how far could we go with the scenarios to save energy and compare which could be useful for the design of options for the future scenarios. The following section gives a brief idea about each of the scenarios:

Scenario #0 - All poles on at maximum level 10 with no lighting control operation.

Scenario #1 - All poles on at maximum level 10 (except for end 3 poles at level 7) with 120 seconds timer settings.

Scenario #2 - All poles on at maximum level 8 (except for end 3 poles at level 7) with 120 seconds timer settings.

Scenario #3 - 7 poles (3+1+3) on at maximum level 10 with 120 seconds timer settings. This scenario was designed specifically with respect to the movement of the user in the space, and the light following him/her. In scenario # 3 and scenario #4, only 7 poles out of the whole 34 poles were programmed to control from highest to lowest light level by presence control system depending on the position of the user, although all the poles are installed with the sensors. Hence (3+1+3) indicates three poles before the current position of the user+ current pole + three poles after the current position of the user.

Scenario #4 - 7 poles (3+1+3) on at maximum level 10 with 60 seconds timer settings. This scenario also was designed specifically with respect to the movement of the user in the space, and the light following him/her, but with much shorter timer settings in order to test the extreme limits for experimentation with the lighting control system.

The following scenarios were summarised and represented in a tabular format after a discussion with the project team:

Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (sec)*
# 0	*10*	*10*	*All*	*- No -*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

(Fig. 3.2) Table showing all the scenarios

QUESTIONNAIRE INFORMATION

As part of the project evaluation, a standard questionnaire was formulated keeping in mind criteria needed for evaluation of each of the scenarios. The questions concentrated on human vision, safety and perception and included range of ages, genders and the mode of transport by the users to provide comparisons in relation to the lighting situation.

There were 5 different scenarios over a period of 5 weeks (each scenario was retained for a week) starting from first week of October (05-10-2012) to first week of November (04-11-2012). It is to be noted that there was no snow during this period of survey; the weather was either windy or rainy most of the days. The trees had good foliage for the initial two weeks but from the third week onwards the trees had shed the leaves broadening the field of vision for the users. All these conditions are assumed to have affected the responses from the people while answering the questionnaire. The interviews were taken between 20.00 hrs – 23.30 hrs every week. A minimum number of 21 responses from the users were collected for each scenario. Light output levels, the timer settings for the control system and the number of poles were the varying factors for the scenarios. The questionnaire was as follows:

QUESTIONNAIRE

1. Male ☐ Female ☐
2. Age : under 20 ☐ 20-40 ☐ 40-60 ☐ 60+ ☐
3. I normally use the area as: Pedestrian ☐ Bicyclist ☐
4. How often do you use this road?
   Rarely ☐ Often ☐ (2-3 times/week) Regularly ☐ (4-5 times/week) Everyday ☐
5. Do you feel safe walking this road?
   Absolutely ☐ Partly ☐ Hardly ☐ Not at all ☐

6. Is the light here enough for what you need to see?
   Absolutely ☐ Partly ☐ Hardly ☐ Not at all ☐

7. How do you judge the lighting situation after changing the light sources?
   Very good ☐ Good ☐ Adequate ☐ Inadequate ☐

8. Did you notice the new lighting situation in the area? Yes ☐ No ☐

9. Please express in short comments about the lighting of the place; suggestions for improvement.

OBJECTIVE OF QUESTIONS

Each of the questions had an objective behind it. The intentions are elaborated as below:

Question 3 and 4 : How often do you use this road and how? As a pedestrian or a bicyclist?

To find out the frequency of usage and mode of transport by the users.

Question 5: Do you feel safe walking this road?

This question solely relates to the feeling of safety while walking down the road.

Question 6: Is the light here enough for what you need to see?

This question relates to the human vision and comfortability and is one of the major aspects for the street lighting concerning the functional aspect purely.

Question 7: How do you judge the lighting situation after changing the light sources?

This question was an indirect approach to get responses how did the people judge the current situation as compared to the old lights, if the people were happy with the light levels and how did they perceive the overall environment. The intention was to see if the light level can be reduced, in case they agree with dimming down of light levels, so as to save some energy wherever possible. But eventually during the course of interviews it was discovered that about 80% of the people didn't notice the new changed LED light sources and thus couldn't tell the difference in the lighting situation comparing to the previous one. Hence all the answers were answered by judging the current situation on the site without any comparison. Hence from now on the question will be just evaluated as – *How do you judge the lighting situation?*

Question 8: Did you notice the new lighting situation in the area?

The intention was to see whether people really pay much attention to the lighting and notice any considerable changes in the overall picture of the place. Also, if they didn't feel anything negative about the change or didn't notice the change for that matter, in a way it suggested that they find it normal and usual, if not anything better.

Question 9: Please express in short comments about the lighting of the place; suggestions for improvement.

This part of the questionnaire was an 'open - discussion' and 'personal opinion' section, where they were free to add any comments or make any suggestions regarding lighting. The objective was to extract the thoughts/ ideas about the lighting situation, also making them feel involved in the process. If they feel part of the process and important, then the people are more likely to develop awareness as well as responsibility towards lighting.

SCENARIO # 0

Conditions for the scenario # 0 - The first scenario (marked in lime colour in the following chart) show the conditions for this scenario. This was a stable situation without any sensor system activated in order to find any significant variation in the responses from people when the sensor system was activated. This served as the basic scenario to make comparisons with later ones.

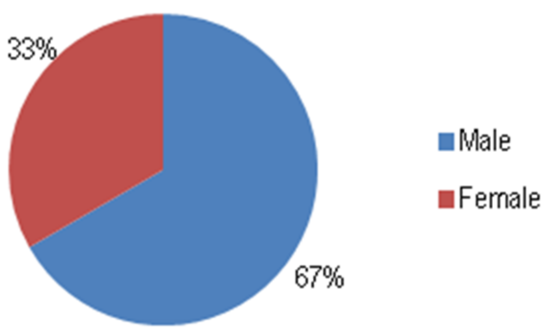
Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*- NO -*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

(Fig. 3.3) Table showing conditions marked for scenario #0

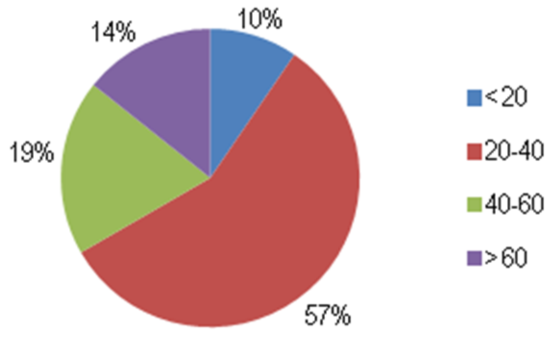
NOTE*:* In all the bar- graphs the results (expressed in percentages), are relative to the column in discussion, i.e. the whole column is considered as the total 100% and the figures in percentages are relative to the respective column.

Results from questions 1 and 2 - Age groups and Gender

The graph (Fig. 3.4) below shows the percentages of men and women and (Fig. 3.5) indicates the distribution of age groups of participants in percentages. The ratio of men was comparatively higher than women. In this scenario, the age group of 20-40 formed the majority (57%) of the participants followed by that of 40-60 (19%). The age group of above 60 and below 20 constituted 14% and 10% respectively.

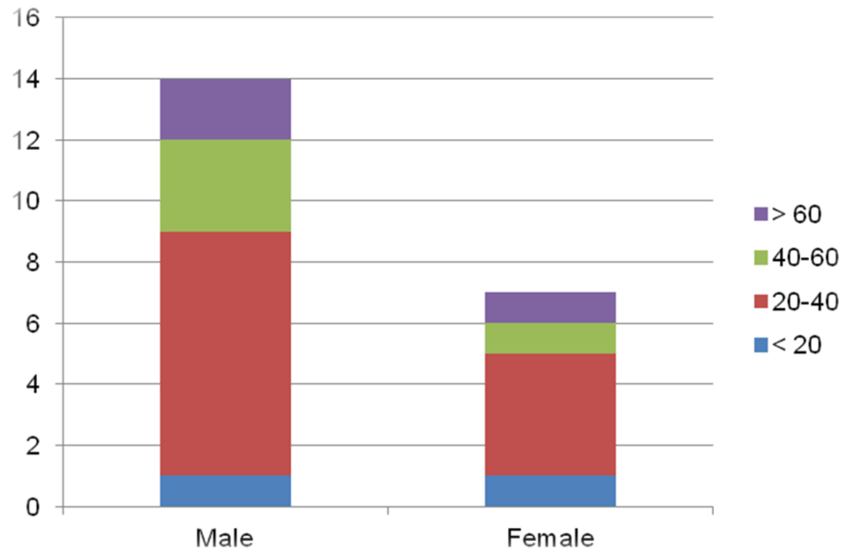


(Fig 3.4) Pie – chart showing percentage of male and female



(Fig 3.5) Pie – chart showing percentage of age groups

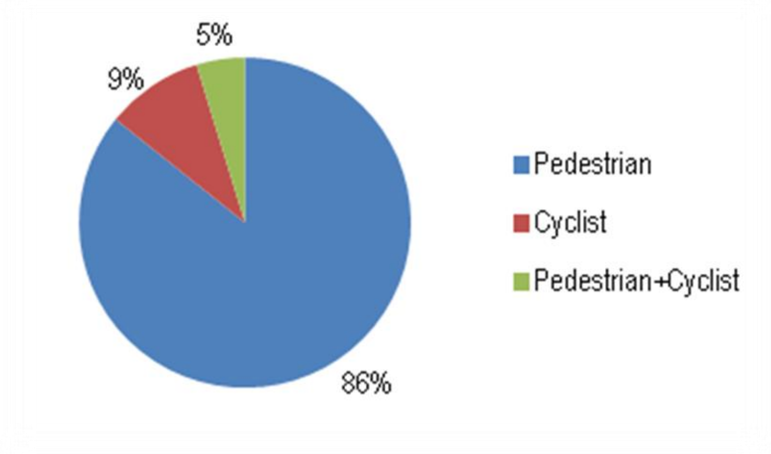
As seen from the bar graph (Fig 3.6), the age group of 20-40 formed the majority of the people interviewed, followed by the group of 40-60. Out of the men who participated (14 in number), 7% were under 20 years of age, 57% were in the age group of 20-40, where as 22% were in the age group of 40- 60 and 14% were in the group of 60 years and above. Coming to the women, who were almost half in number as compared to men, about 14% of them were under 20 and above 60 years of age, where as it was close to the figures with men, i.e. 57% and 15% comprised of the age group of 20-40 and 40-60 respectively.



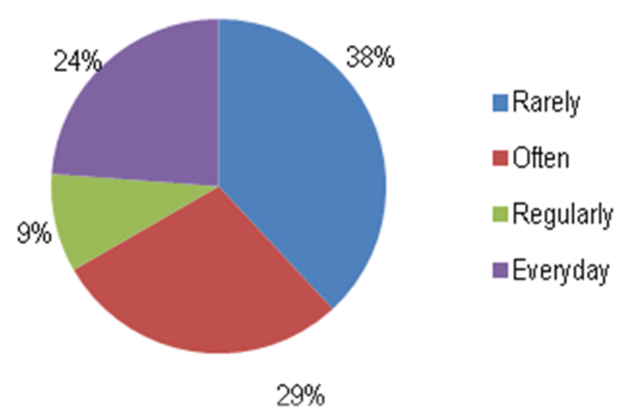
(Fig 3.6) Bar graph showing gender vs age groups

Q. 3 and 4.How often do you use this road and how? As a pedestrian or as a bicyclist?

Results - The graph (Fig 3.7) below shows the percentages of different kind of users, i.e., pedestrians, bicyclists and people who use the road for both (As a pedestrian as well as bicycling). (Fig 3.8) shows the frequency of the users in the space.

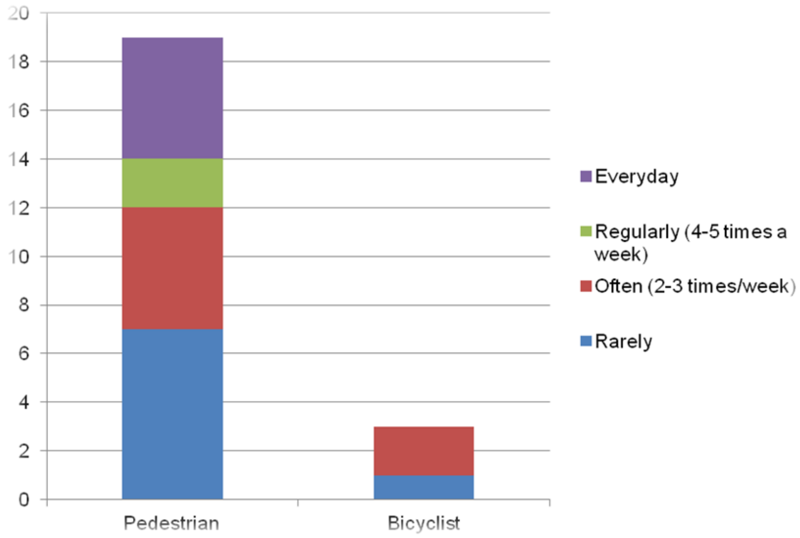


(Fig 3.7) Pie – chart showing percentage of mode of users



(Fig 3.8) Pie – chart showing percentage of frequency of users

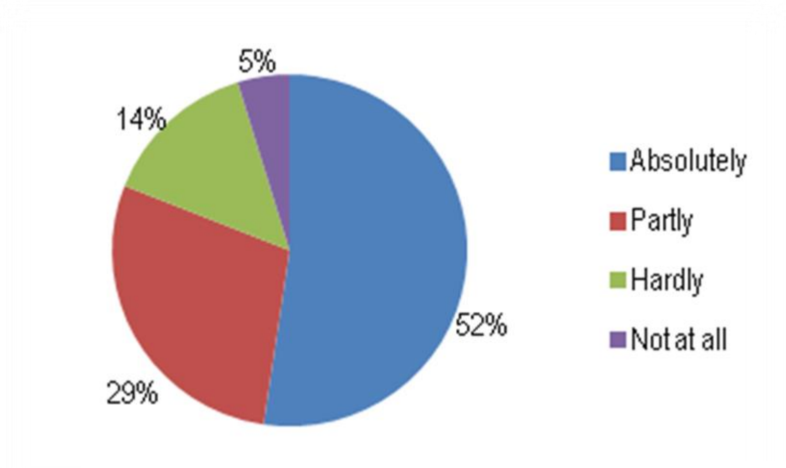
Out of the pedestrians, who formed the majority of the users, 37%, 26%, 11% and 26% used the route rarely, often, regularly and everyday respectively. Counting the bicyclists, who were 3 in number, 1 of them took this route rarely where as the other two used it often. (Fig 3.9)



(Fig 3.9) Bar graph showing mode of transport and frequency of users

Q5. Do you feel safe while walking on this road?

Results - As it can be seen in (Fig 4.0), more than half of the people interviewed felt absolutely safe while on the road with no threat at all while 29% of the population interviewed felt partly safe. 14% of the people felt hardly safe in the space, while the remaining 5% didn't feel safe at all.

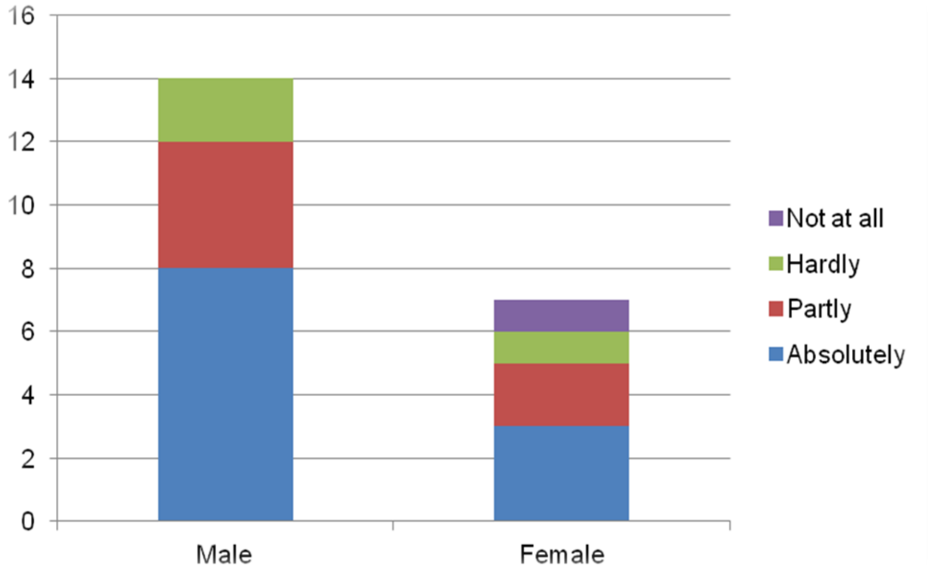


(Fig 4.0) Pie – chart showing percentage of safety

Safety versus Gender

Out of all the men (14 in number) who polled, 58% felt absolutely safe, 28% felt partly safe, and remaining 14% felt it was hardly safe while walking on the road. While comparing with the statistics with the female population, 43% felt absolutely safe, 28% felt partly safe, 15% felt hardly safe and 14% (which was just one woman) didn't feel safe at all. (Fig 4.1)

Observations - However, 68% of the whole lot were men, and 32% were women, pointing towards the fact that men felt safe in general, which they agreed to, while interacting with them. It can be concluded that the perception of safety varies with gender, and it wouldn't be wrong to say that men felt more secure than women, affirming the general assumption.

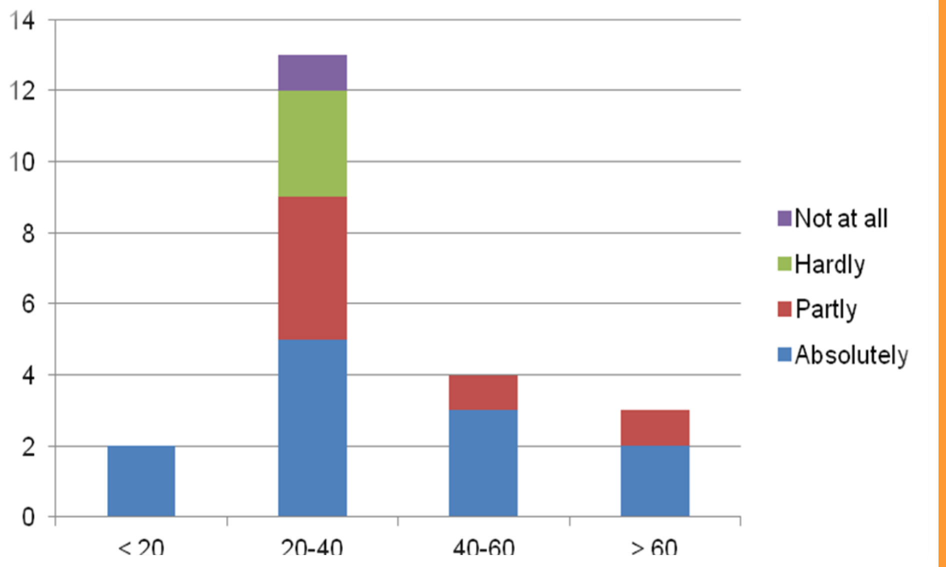


(Fig 4.1) Bar graph showing safety vs gender

Safety versus Age group

It is quite intriguing to analyse if the perception of safety also varies with changing age groups like with gender. Coming to the statistics, 100% of the people interviewed under the age 20, felt absolutely safe in the environment. In the age group of 20-40, 34% of the people felt absolutely safe, 33% were skeptical about the absolute safety, 25% felt hardly safe and 4% believed that they were totally unsecure. In the age group of 40-60, 75% felt absolutely safe and remaining 25% felt partly safe. In the older age group, 67% felt absolutely safe and 23% felt partly safe. (Fig 4.2)

Observations - It was interesting to see the findings in this case. The people from the age group of 20-40 formed a big amountable 60% size of the total

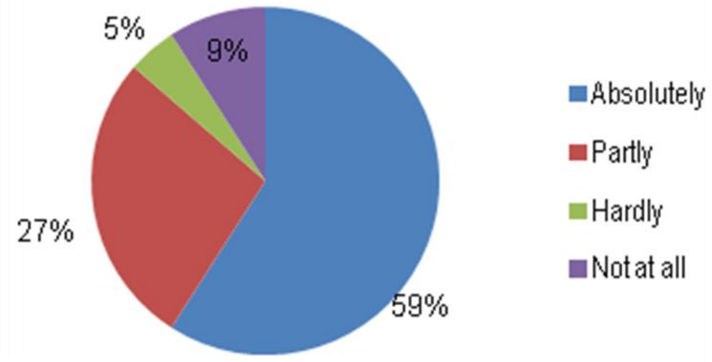


(Fig 4.2) Bar graph showing safety vs age group

people participating in the survey, and also were the ones who felt most vulnerable, dismissing the assumption of higher degrees of feeling of insecurity among the older generation. But, the results from the under 20 and above 60 group cannot be considered fully accurate as there were just 2 and 3 people respectively in the bunch of 21 people. The safety quotient among the other age groups seems fair.

Q6. Is the light here enough for what you need to see?

Results - It was an overwhelming response of 59% of people who seemed to be totally satisfied with the quality of light required for their vision. However, there were just 3 persons above the age of 60, making the responses biased more towards the younger age groups. 27% of the people felt that it could be improved a bit in terms of brightness level, and 2 people strongly felt that the light was not enough at all. So overall, the general idea was satisfactory although it concentrates more on the age groups of 20-40 and 40-60. (Fig 4.3)

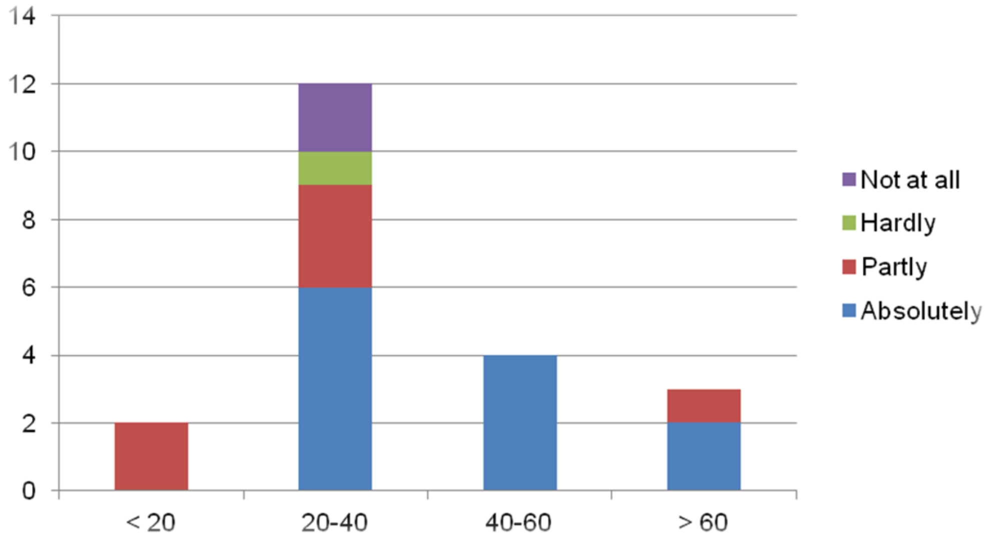


(Fig 4.3) Pie – chart showing responses towards visual comfortability in percentages

Visual comfortability versus Age group

100% of the people interviewed in the age group of under 20 felt the light was partly good enough to see in the environment. The age group of 20-40 had wide range of answers towards the light in the space. 50% said that it was absolutely good, 25% felt it was partly good, 9% believed that it was hardly enough to see, where as 16% felt the light was not at all enough. In the age group of 40-60, 100% of the people that it was perfectly good enough and they could see clearly. For 67% of the elderly people, the light was absolutely good enough and for 23% of them, it was partly enough. (Fig 4.4)

Observations - Similar to the case of safety vs age group, the people from the group of 20-40 years have varied responses regarding the visual comfortability, although majority of them feel the light is absolutely enough

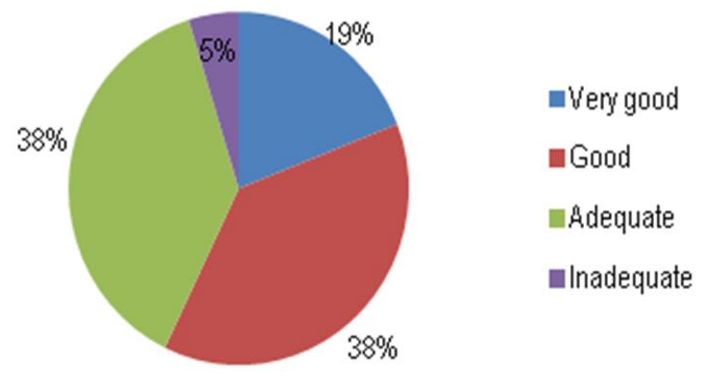


(Fig 4.4) Bar graph showing Visual comfortability vs age group to see things clearly. Also, surprisingly 2 of them were completely unsatisfied with the light and said that it was not at all enough for them to see. The people from the age group of 40-60 proved to be the most satisfied bunch, where as the older generation were satisfied to certain extent, if not completely. Also, the youngest people were partly satisfied with the light. Hence, in this case, the responses didn't really comply with the general idea of need of more light with increasing age.

Q7. How do you judge the lighting situation?

Results - 38% of the people were satisfied with the light level and responded as 'good' although this time the majority of them didn't go for the 'perfect' option. Another 38% believed that it was adequate and 5 % felt the necessity either to brighten it up or improve in some way as it was inadequate for them. A reasonable amount of 19% responded that the light was very good and they are comfortable while taking the road. (Fig 4.5)

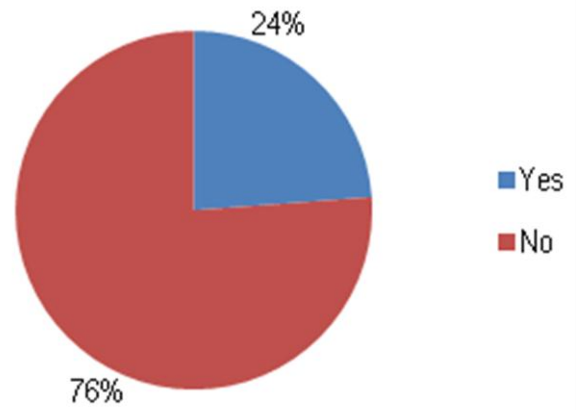
Observations - Overall response from the people was satisfactory with only 5% of them being completely unsatisfied with the whole scenario and equal number of people finding it to be adequate as well as good.



(Fig 4.5) Pie – chart showing response towards lighting situation in percentages

Q8. Did you notice the new lighting situation in the area?

Results - This was an interesting part to document, as 76% of the people had not noticed any change in the lighting situation; while a mere 24% said they are aware of it. Out of the 24%, most of them had read about it by medium of display boards by the Municipality about the project and the rest had noticed the change of luminaires. When asked consciously, they instantly could differentiate the change, and appreciated the lighting condition at the experimental stretch more than the old lighting condition. (Fig 4.6)



(Fig 4.6) Pie – chart showing response towards noticing of new lighting installation in percentages

Responses and suggestions from people:

Summary of the comments

This section provided useful insights into the lighting situation and the reaction of people towards it. Out of the different aspects which people expressed their comments/ suggestions, the most important of them could be broadly summarised into the following categories:

1. Lighting levels and distribution - Too bright light levels can result in creating strong contrast levels with the surrounding atmosphere, which is not appreciated. Attention needs to be paid to infuse more homogenous situation with appropriate hierarchy in lighting blending into the atmosphere, to avoid the imbalanced light levels which try to compete with each other in the environment. People preferred to see the lights on continuously, without going off anytime and felt the need to have more light while entering into the area. Although quite a few of them expressed that it could be brighter, but most of the people who asked for brighter light levels were concerned with the safety issues, which would be follow in the discussion. One of them mentioned that with age, people certainly need more light.

2. Safety - Among the female population, whoever suggested the desire for brighter levels of light, associated it directly with safety, although one of them indicated that it wasn't about the lighting, but about the people, their presence or absence on the road, which changes the perception of safety altogether. The time of the day also plays an important role in the perception of safety; some admitted that they wouldn't like to use the road if it's not constantly lit during late in the night. Hence, perception of safety, light levels and time of the day, all these factors are inter-linked.

3. Overall atmosphere and feelings - Majority of the people agreed that the light was good and felt cosy in the place. The general opinion about the overall atmosphere was to have a more surrounding light, which could influence the perception of safety as well as sub-consciously broaden the field of vision for people. This could be done by perhaps lighting the tree trunks or foliage as suggested by the users.

4. Colour of light - Only three people out of the whole crowd mentioned about the colour of the light from the light sources in the installation. While one said that the colour of the light in the installation is better than the yellow colour of Sodium vapour lamps on the other side of the waters, another person expressed that the current light looks a bit greenish (colder).The third user preferred bit warmer light but was happy with the light levels and distribution.

5. General - Comments from the bicyclists play a vital role in the discussion, as technically speaking, they constitute half of the type of users in the space. One of them was really appreciative of the idea of using presence control sensor systems for lighting (in the forthcoming scenarios). He found it as a warning system for the bicyclists, who usually are at much higher speed as compared to pedestrians, to become alert from a distance and realise when there are people on the road, as the lights would change their levels detecting motion in the field. Also, he found this idea responsible for a good, sustainable future. One of them desired to have security cameras installed along the stretch for security issues.

SCENARIO # 1

The conditions for the scenario # 1

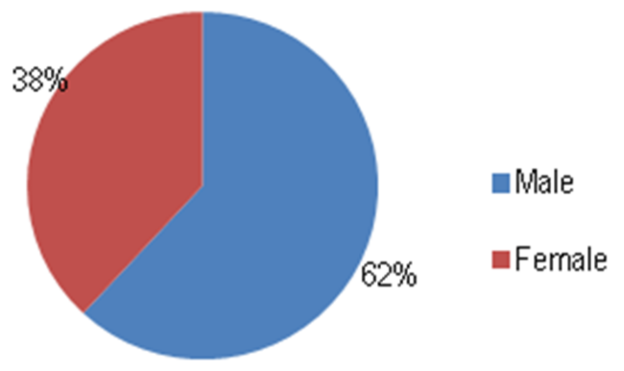
The scenario number 1 was the first scenario with activated presence control sensor system. From here on, all the scenarios would use lighting control systems. The scenario marked in lime colour in the following chart shows the conditions for this scenario.

Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*- NO -*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

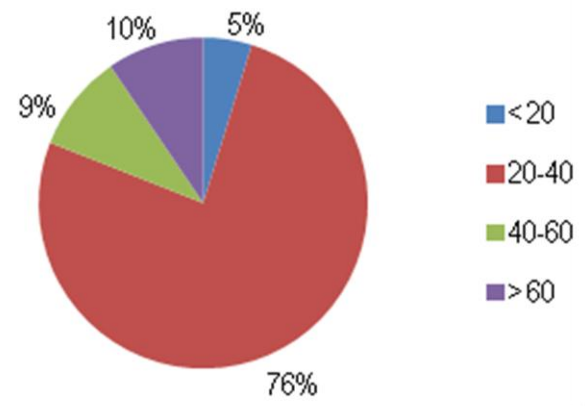
(Fig 4.7) Table showing conditions marked ofr scenario #1

Results from questions 1 and 2 - Age groups and Gender

The graph (Fig 4.8) below shows the percentages of men and women and (Fig 4.9) indicates the distribution of age groups of participants in percentages. The number of men was comparatively very high like the earlier scenario #0. Also, in this scenario, the age group of 20-40 dominated with high numbers (76%), and 40-60, above 60 and below the age of 20 constituted only 9%, 10% and 5% of the total.

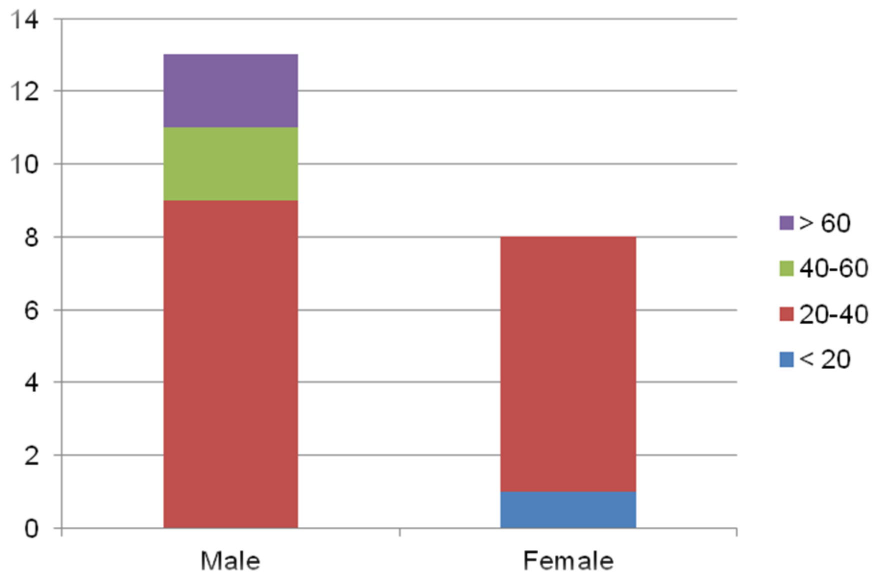


(Fig 4.8) Pie – chart showing percentages of male and female



(Fig 4.9) Pie – chart showing percentages of male and female

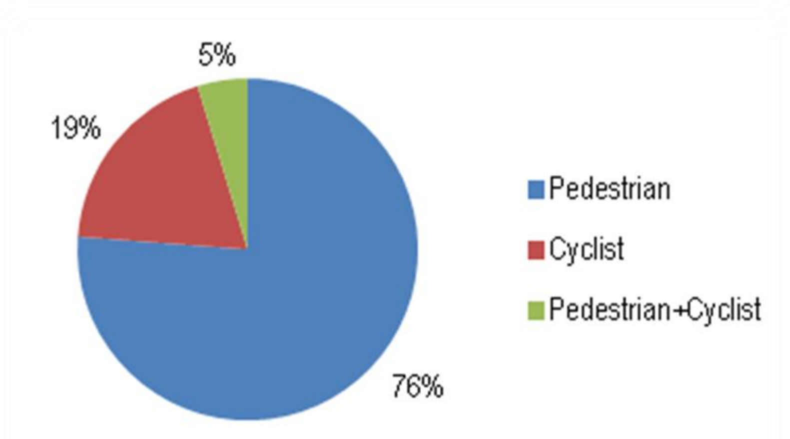
Like the previous case, the age group of 20-40 formed the active participation group, followed equally by the group of 40-60 and 60+. Out of the men who participated, 70% were in the age group of 20-40, where as 15% were in the age group of both 40- 60 and 60+ each. Coming to the women, who were 1 more in number as compared to last time, there was the only participant under the age of 20, and all the rest 7 of them (87%) were from the age group of 20-40. (Fig 5.0)



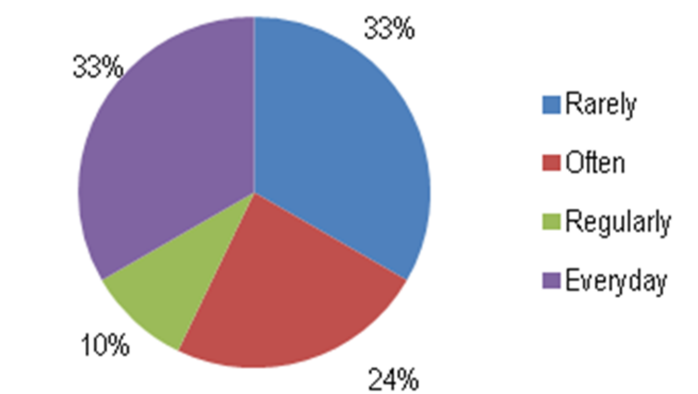
(Fig 5.0) Bar graph showing percentages gender vs age group

Q. 3 and 4.How often do you use this road and how? As a pedestrian or as a bicyclist?

Results - The graph (Fig 5.1) below shows the percentages of different kind of users, i.e., pedestrians, bicyclists and people who use the road for both (As a pedestrian as well as bicycling). (Fig 5.2) shows the frequency of the users in the space.

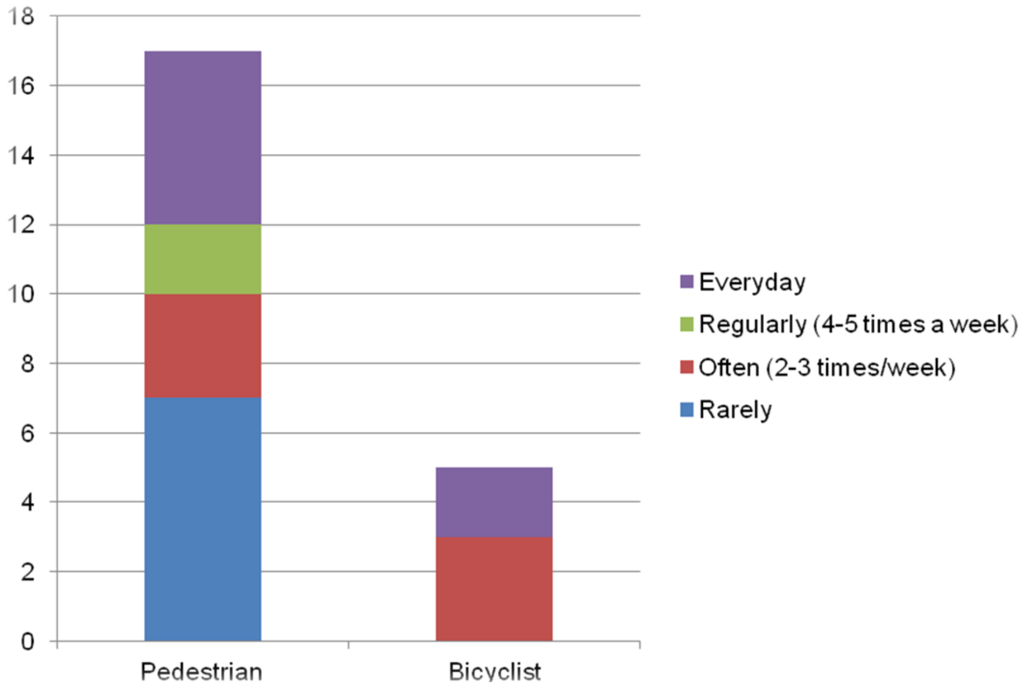


(Fig 5.1) Pie chart showing percentage of mode of users



(Fig 5.2) Pie chart showing percentage of frequency of users

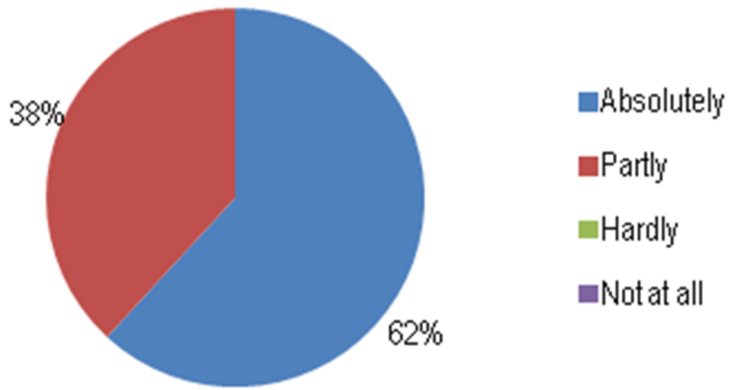
Out of the pedestrians, who formed the majority of the users, 42%, 17%, 12% and 29% used the route rarely, often, regularly and everyday respectively. Counting the bicyclists, who were fortunately 5 in number, 60% of them took this route often, while 40% took this road on an everyday basis. (Fig 5.3)



(Fig 5.3) Bar graph showing mode of transport and frequency of users

Q5. Do you feel safe while walking on this road?

Results – Interestingly, there were just two kind of responses unlike the previous scenario. As it can be seen 62% of the people interviewed felt absolutely safe on the road with no threat at all while the remaining 38% of the population interviewed felt partly safe. There were no reactions indicating any kind of insecure feeling while in the space, which was very positive. (Fig 5.4)

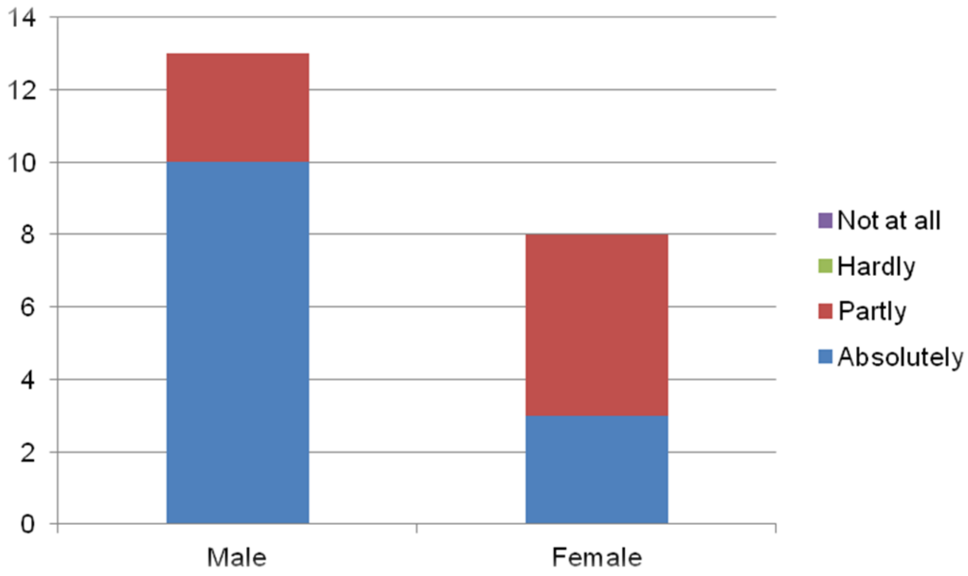


(Fig 5.4) Pie chart showing percentage of safety

Safety versus Gender

Out of all the men (13 in number) who polled, 77% felt absolutely safe and 23% felt partly safe while walking on the road. When compared with the statistics with the female population, 38% felt absolutely safe, while the remaining 62% felt partly safe. (Fig 5.5)

Observations – Although the men form the majority of the user group, still there was interesting data with this scenario. Surprisingly, there was a positive increase in the perception of safety in general, by terminating the 'hardly safe' and 'not at all safe' responses from the questionnaire. As always, when compared, the female users were skeptical about going with the absolute safeness idea, but still the answers this time depicted the idea of 'security'.

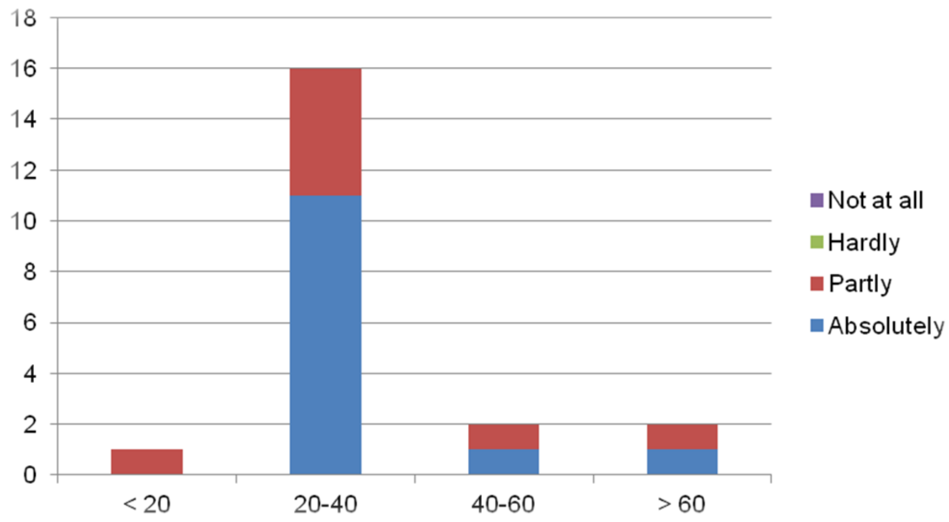


(Fig 5.5) Bar graph showing safety vs gender

Safety versus Age group

While analysing the bar-graphs, it is clear that people from different age groups, feel quite safe in general. The only girl under the age of 20 felt partly safe in the environment. This might be subjected to the gender of the user. 69% felt absolutely safe, and the remaining 31% felt partly safe in the age group of 20-40. In the age group of 40-60 and above 60, there was a clear 50-50 split up among absolute and partial perception of safety. (Fig 5.6)

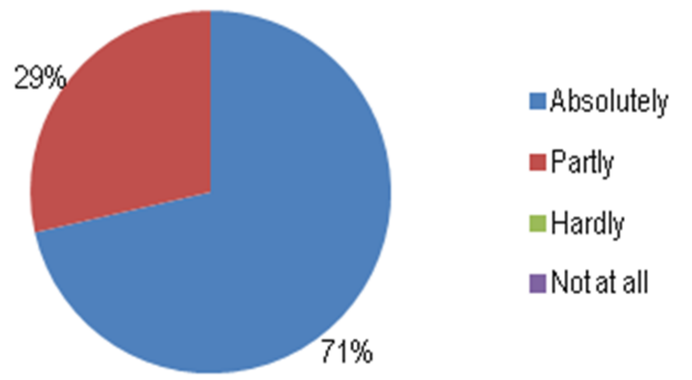
Observations - The results in this case indicate a positive outcome with the scenario settings. Similar to the previous discussion of safety vs gender, this discussion also provides satisfactory results with the sense of security among people.



(Fig 5.6) Bar graph showing safety vs age group

Q6. Is the light here enough for what you need to see?

Results – It was an overwhelming response of 71% of people who seemed to be totally satisfied with the quality of light required for their vision. However, a bit more than one-fourth (29%) didn't agree that it was the best, and said that it was partly good for visual clarity. So overall, the response was positive and satisfactory. (Fig 5.7)

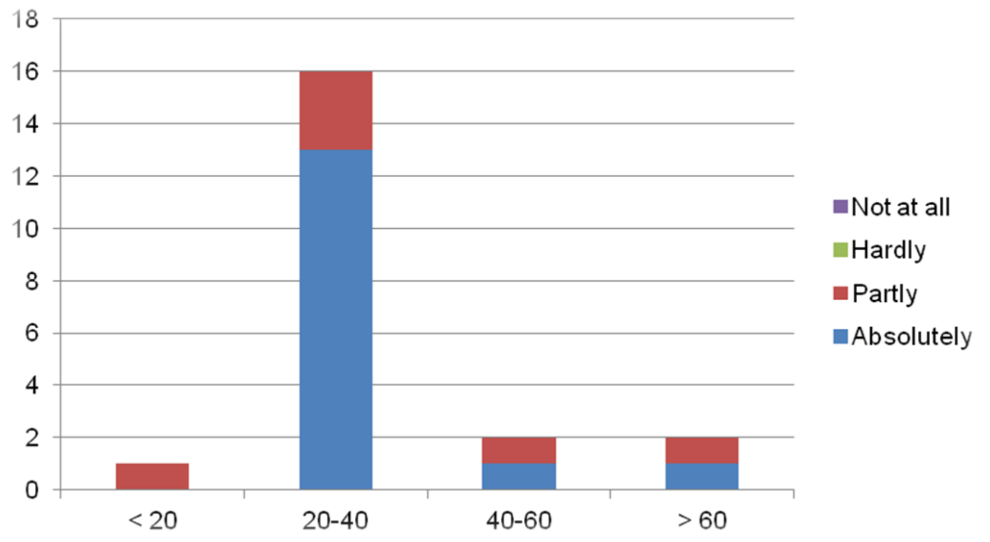


(Fig 5.7) Pie chart showing responses towards visual comfortability in percentage

Visual comfortability versus Age group

What must be noticed here is that the youngest lot seems to feel that the light is partly good to see 'what one needs to see', like in the earlier scenario #0. In the age group of 20-40, 81% felt absolutely good, and 19% felt it was partly good. In the age group of 40-60 and above 60; it was again the same case as safety perception; 50% going for the 'absolutely' option and the other 50% with the 'partly' option.(Fig 5.8)

Observations - Similar to the case of safety vs age group, the people from the group of 20-40 years have more or less similar responses regarding the visual comfortability also, although majority of them feel the light is absolutely enough to see things clearly. None of the people were unsatisfied with the light and vision. The people from the age group 40-60 and above 60 had completely same responses about the comfortability in the light, in a way indicating similar kind of need regarding lighting in a space in older age groups.

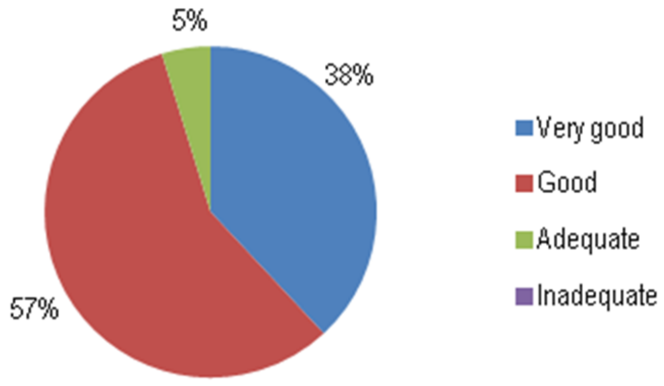


(Fig 5.8) Bar graph showing responses towards visual comfortability in vs age group

Q7. How do you judge the lighting situation?

Results – 38% of the people thought that the light was very good along with the whole atmosphere. 57% believed that it was good if not perfect, and 5% (1 out of 21 people) felt that it was just adequate. There was a great improvement in the satisfaction levels with the light in this scenario as compared to the previous one. (Fig 5.9)

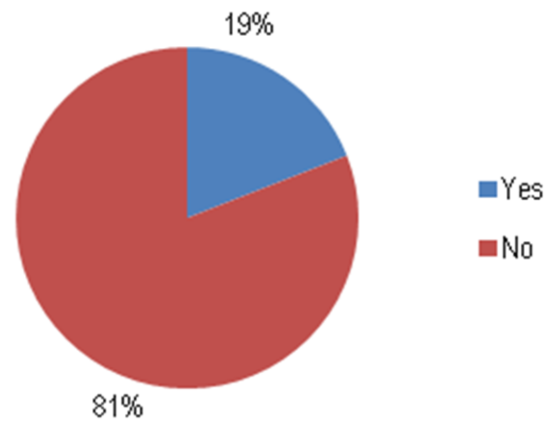
Observations - There was a great improvement in the satisfaction levels with the light in this scenario as compared to the previous one, even if the light levels were the same for both the scenarios.



(Fig 5.9) Pie – chart showing response towards lighting situation in percentages

Q8. Did you notice the new lighting situation in the area?

Results – 81% of the people had not noticed any change in the lighting situation; while a mere 19% said they are aware of it. Out of the 18%, most of them had witnessed other people taking the survey or had participated earlier. (Fig 6.0)



(Fig 6.0) Pie – chart showing response towards noticing of new lighting installation in percentages

Responses and suggestions from people:

Summary of the comments

1. Lighting levels and distribution – There were mixed responses regarding the comments based on light levels. Surprisingly, some of the users felt the light could be softer and can be dimmed down a bit as they didn't prefer too much light. Some of the people felt the need for more light thinking that it would make the place look brighter and better, especially in the winter period, where as the rest judged the situation to be very good as it was and agreed to feel satisfied with the light situation.

2. Safety – None of the users in this scenario complained about lower light levels and associated it with the perception of safety, although all of them indicated that it wasn't about the lighting, but about the area, time of the day, the surrounding dark tree foliage and people, their presence or absence on the road, which changes the perception of safety altogether. One of the female participants strongly stated that she never felt unsafe while walking alone at any time of the day, as she takes this route alone on weekends very late in the night or early in the morning, while coming back from work. Another woman mentioned that she would still feel very unsafe even if the light levels were doubled.

3. Overall atmosphere and feelings – Most of the respondents found the overall situation to be good and one of them even insisted on installing the same lights in a stretch in the neighbouring street, where it was much darker and visually unclear. Few men were skeptical about their female counterparts walking alone on this road. Men somehow weren't sure whether the women would feel safe in the environment.

4. General – Incorporating some attractive decorative light was one of the suggestions made by a user. In general, people are appreciative of the idea of lighting control systems for energy saving. One of the user mentioned that the installation stretch is quite nice, but areas beyond the bridge (old installation), is a place for alcoholics and drug addicts and strongly feels that the place can be changed with proper lighting.

SCENARIO # 2

The conditions for the scenario # 2

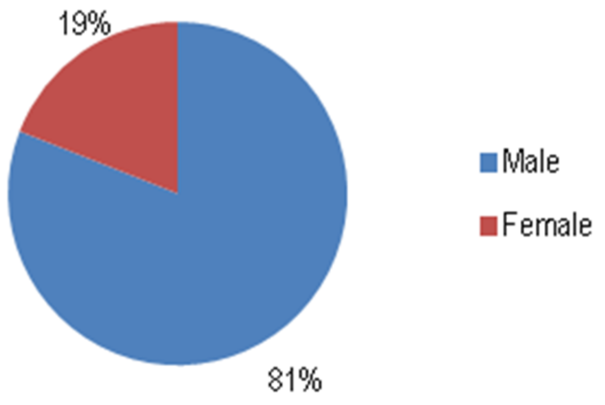
The scenario marked in lime colour in the following chart shows the conditions for this scenario.

Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*--*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

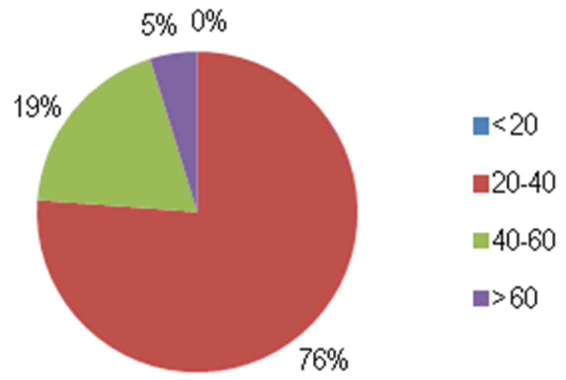
(Fig 6.1) Table showing conditions marked for scenario #2

Results from questions 1 and 2 - Age groups and Gender

The graph (Fig 6.2) below shows the percentages of men and women and (Fig 6.3) indicates the distribution of age groups of participants in percentages. The ratio of men to women was almost 4:1. The age group of 20-40 again formed a big majority of the participants by 76%, like in previous the cases. The age group of 40-60, made up to 19% of the participants followed by 5% (only one) from the group of above 60.

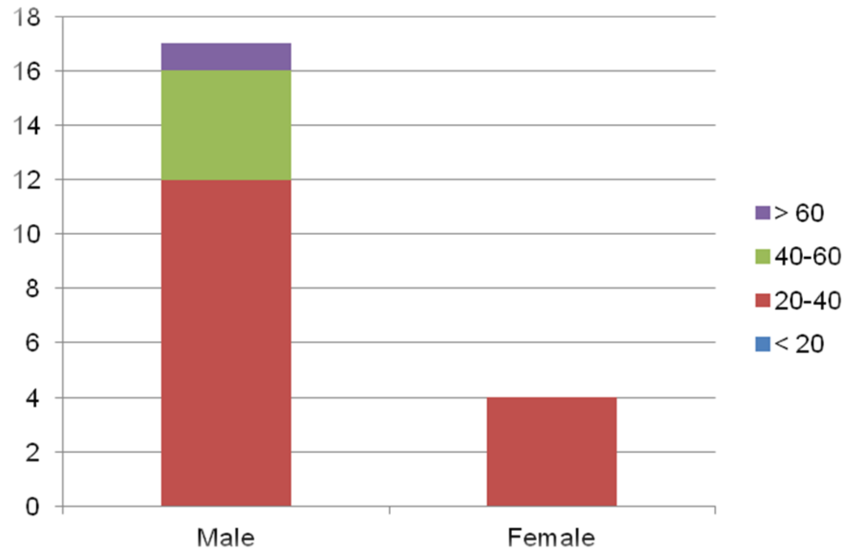


(Fig 6.2) Pie chart showing percentage of male and female



(Fig 6.3) Pie chart showing percenatge of age groups

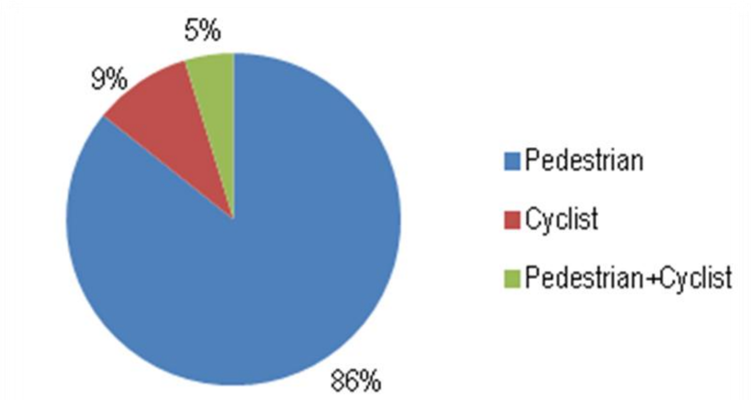
Out of the men interviewed (17 in number), there were none in the age group of less than 20, 70% were in the age group of 20-40, 24% (94-70%) were in the age group of 40- 60 and only 1 person which made 6% of the people interviewed, was in the group of above 60. Coming to the women, who unfortunately formed a very small percentage in this scenario, all were a part of younger age group of 20-40. (Fig 6.4)



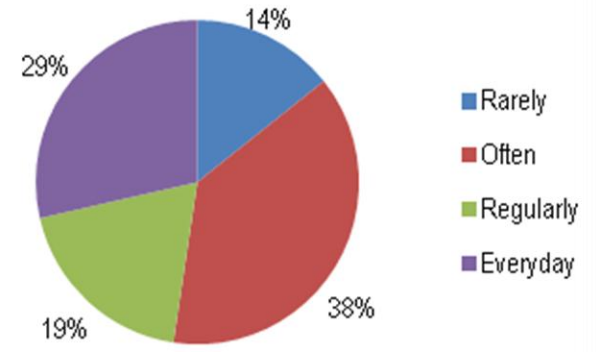
(Fig 6.4) Bar graph showing gender vs age group

Q. 3 and 4.How often do you use this road and how? As a pedestrian or as a bicyclist?

Results - The graph (Fig 6.5) below shows the percentages of different kind of users, i.e., pedestrians, bicyclists and people who use the road for both (As a pedestrian as well as bicycling). (Fig 6.6) shows the frequency of the users in the space.

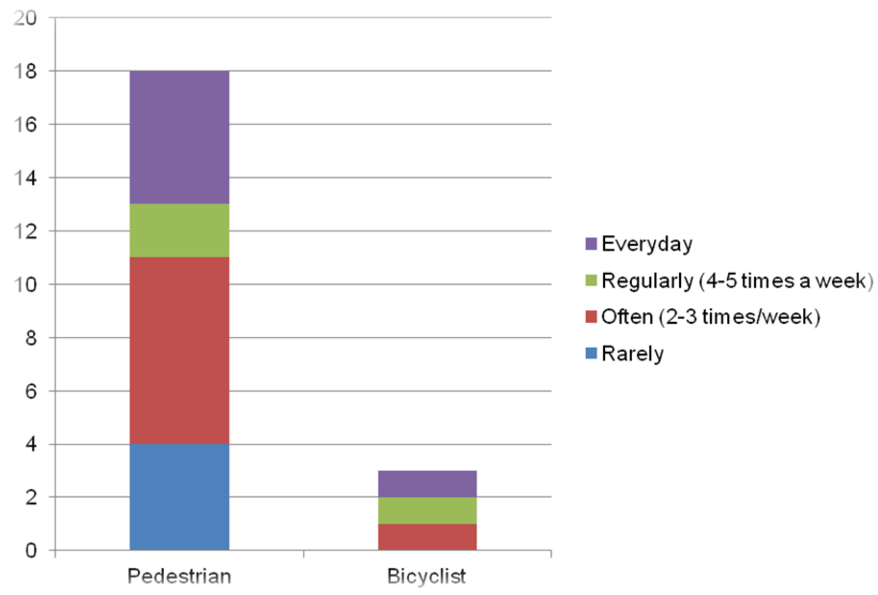


(Fig 6.5) Pie chart showing percenatge of mode of users



(Fig 6.6) Pie chart showing percenatge of frequency of users

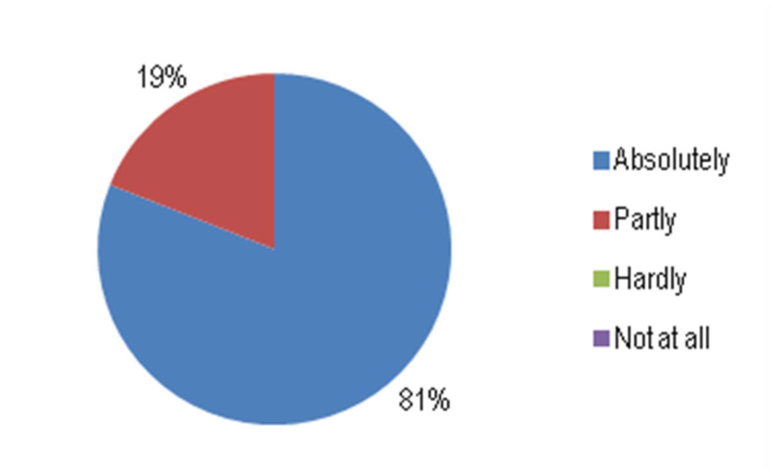
Out of the pedestrians, who formed the majority of the users, 22%, 39%, 11% and 28% used the route rarely, often, regularly and everyday respectively. This time the people using the road rarely were lesser in number and there was an increase in the ones using often. Counting the bicyclists, who were 3 in number, 35% of them took this route rarely, while 32% and 33% were the figures for who took this road regularly and on an everyday basis respectively. (Fig 6.7)



(Fig 6.7) Bar graph showing mode of transport and frequency of users

Q5.Do you feel safe while walking on this road?

Results –Yet again, there were just two kind of responses similar to the previous scenario. As it can be seen, 81% of the people interviewed felt absolutely safe on the road with no threat at all while the remaining 19% of them felt partly safe. It is apparent that people felt more secure in the environment with lighting controls, which indicates to be a good point for the installation (Fig 6.8).

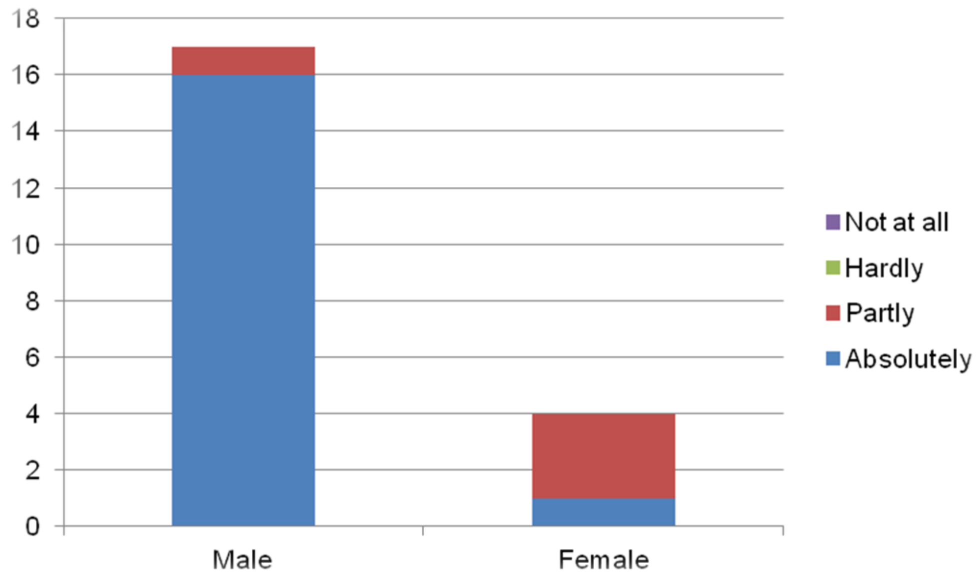


(Fig 6.8) Pie chart showing percentage of safety

Safety versus Gender

Out of all the men(17 in number) who polled, 94% felt absolutely safe, and a mere 6% (1 person) felt partly safe. Analysing the data for the female population, Only 1 among the 4 interviewed felt absolutely safe, where as the rest 3, (75%) felt partly safe. (Fig 6.9)

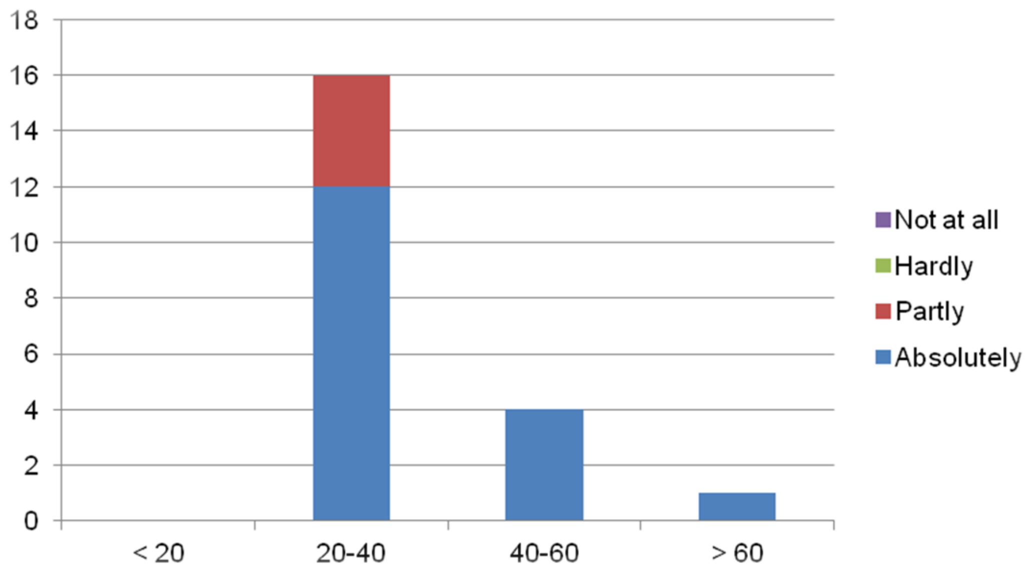
Observations – Looking back at the earlier scenario # 1, there was a positive increase in the perception of safety among men, but a slight decrease in the perception of absolute safety among women. None of the genders felt any less than 'partly safe', hence making the scenario rated as satisfactorily safe.



(Fig 6.9) Bar graph showing safety vs gender

Safety versus Age group

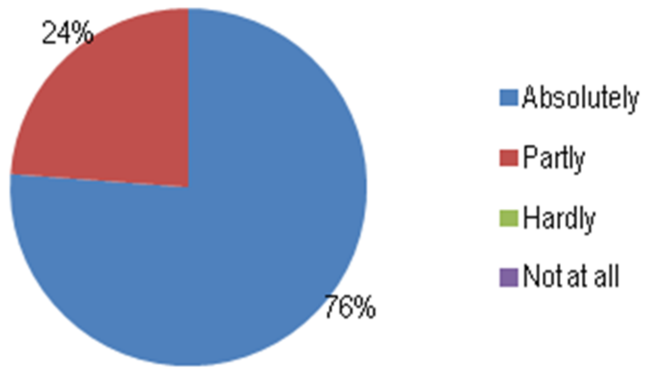
This time there were no participants under the age of 20, not allowing any kind of comments to be made for the youngest group. While analysing the bar-graphs, it is clear that people from the rest of the age groups, feel absolutely safe except for a few percentage of people from 20-40 feeling partly safe. Considering the younger group of 20-40, 80% felt absolutely safe, followed by 20% of people feeling partial safeness. The middle aged group of 40-60 and the only old man in the bunch seemed to feel absolutely secure in the space (Fig 7.0).



(Fig 7.0) Bar graph showing safety vs age group

Q6. Is the light here enough for what you need to see?

Results – It was a clean sweep of 76% of people responding to be totally satisfied with the quality of light required for their vision. However, a percent less than one- fourth (24%) didn't agree that it was the best, and said that it was partly good for visual clarity. So overall, the response was positive and satisfactory. (Fig 7.1)

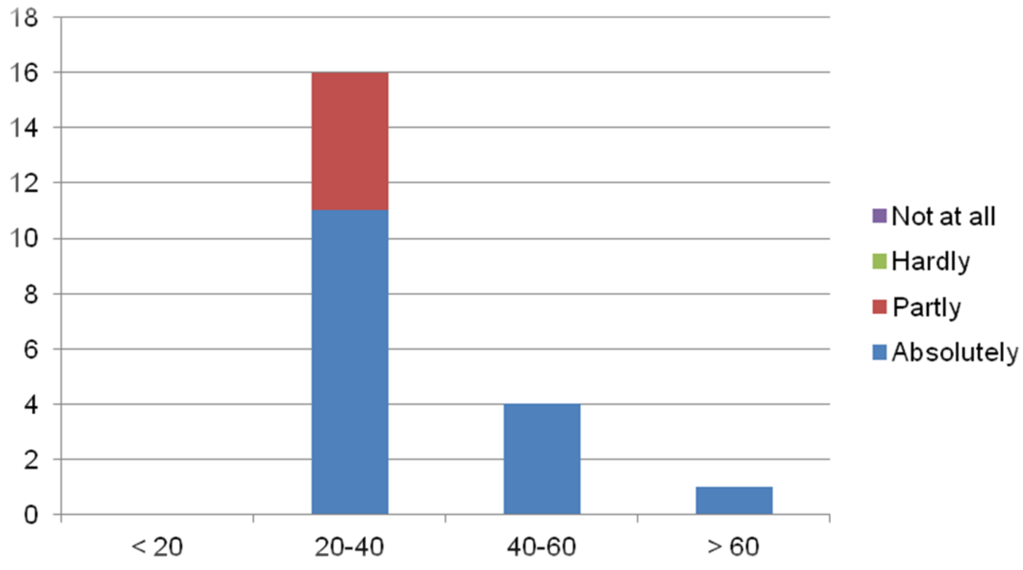


(Fig 7.1) Pie chart showing visual comfortability in percentages

Visual comfortability versus Age group

Since the youngest age group had no participants, no conclusions can be drawn for the same. 69% from the younger age of 20-40 group seemed to feel absolutely good about the light in terms of visual clarity and 31% felt it was partly good. In the age group of 40-60 and above 60, it was the same response; both of the age groups felt that the light was absolutely good for their vision to see things and distinguish with clarity. (Fig 7.2)

Observations - Similar to the case of safety vs age group, the people from the group of 20-40 years have more or less similar responses regarding the visual comfortability also, although majority of them feel the light is absolutely enough to see things clearly. None of the people were completely unsatisfied with the light and vision. The people from the age group 40-60 and above 60 had completely same responses

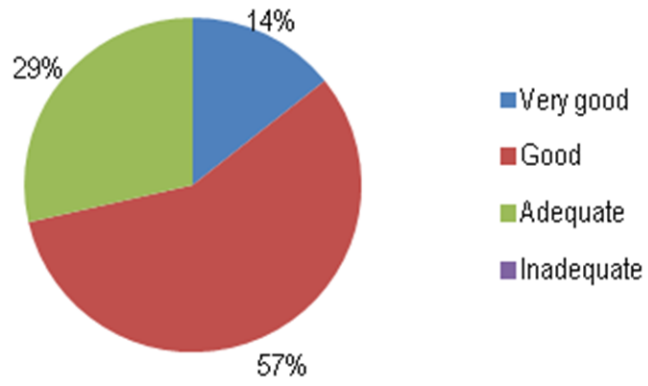


(Fig 7.2) Bar graph showing visual comfortability vs age group about the comfortability in the light, and this time 100% satisfied unlike the previous case, in a way indicating similar kind of need regarding the lighting in a space in older age groups.

Q7. How do you judge the lighting situation?

Results – 14% of the people though that the light was very good along with the whole atmosphere. 57% believed that it was good if not perfect, and 29% felt that it was adequate. There was a slight change in the statistical results compared to the scenario#1. Majority of the people believed that the light was 'good', but this time followed by people thinking it to be adequate and a much lesser percentage of them perceiving it as 'very good' (Fig 7.3).

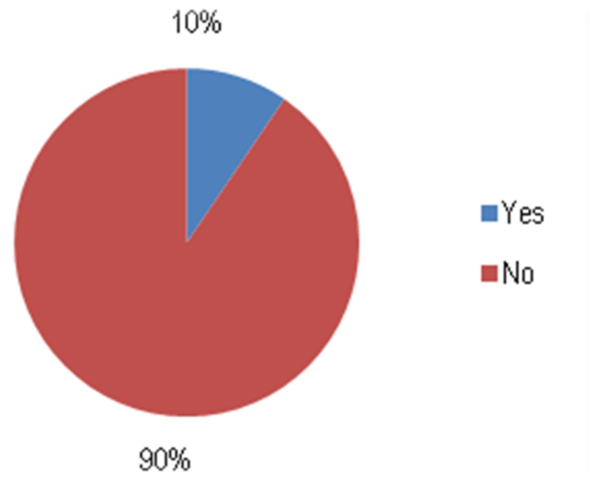
Observations – The satisfaction levels were quite fair though there was a slight decrease in the degree of satisfaction from scenario#1 which had the maximum level of 10 unlike this scenario which had the maximum light level of 8.



(Fig 7.3) Pie chart showing response towards lighting situation in percentages

Q8. Did you notice the new lighting situation in the area?

Results – 90% of the people had not noticed any change in the lighting situation; while a mere 10% said they are aware of it. Out of the 10%, most of them, like before, had witnessed other people taking the survey or had participated earlier (Fig 7.4).



(Fig 7.4) Pie chart showing response towards noticing of new lighting installation in percentages

Responses and suggestions from people:

Summary of the comments

1. Lighting levels and distribution – People responded the same way as in the case of scenario #1, (though there was a considerable difference in levels of light, in a way suggesting that probably the people didn't perceive the difference in the light levels so clearly) some of them suggesting the light to be brighter, some being happy with the existing situation and one of them calling it as 'too bright' light. However in this case, one of them found the lack of proper surrounding ambient light with lights just focussing on the horizontal road surface and not on the vertical planes.

2. Safety – Users feel that if the surrounding areas (trees, bushes or any foliage) are lit well, the environment certainly could feel safer. It would prevent any person hiding behind the trees/ bushes, or visually alert the user if there were any.

3. Overall atmosphere and feelings - Majority of the people agreed that the light was good and felt cosy in the place.

4. Colour of light - Only one user suggested that the light could be a bit warmer but was happy with the light level.

5. General – One of the users had an argument about the idea of regulating the light levels on the pedestrian road in order to save energy. He questioned the proposal and supported his statement by raising questions about not implementing the energy saving criteria on various other places e.g. shop windows, public buildings which are always kept on for the whole night. He strongly feels that it is better to regulate energy usage in those cases rather compromising on bright light levels for the pedestrian street lighting.

Another interesting suggestion was to carry out this test installation during the winter period, as the situation would be completely different with snow around.

One of the users felt that the existing situation was good, but would be better if the light poles were placed closer to each other avoiding the darker regions in between the poles.

SCENARIO # 3

The conditions for the scenario # 3

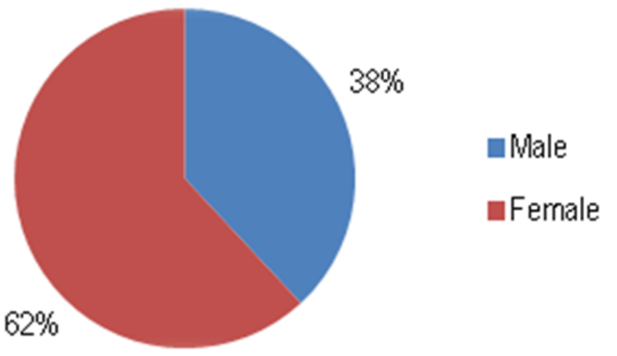
The scenario marked in lime colour in the following chart shows the conditions for this scenario.

Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*--*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

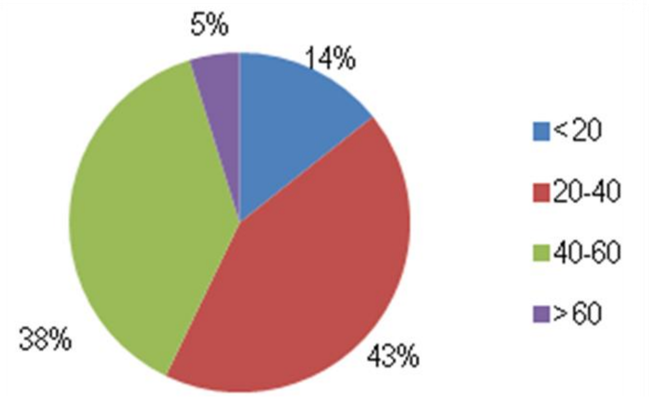
(Fig 7.5) Table showing conditions marked for scenario #3

Results from questions 1 and 2 - Age groups and Gender

The graph (Fig 7.6) below shows the percentages of men and women and (Fig 7.7) indicates the distribution of age groups of participants in percentages. The number of women was comparatively very high as opposed to the earlier scenarios. Also, in this scenario, there was a close call between the age group of 20-40 and 40-60 deciding the most proactive participant age group. The age group of 20-40, yet again comprised of the maximum of 43% followed closely by 38% from the group of 40-60. There was 14% of participation from the group of lesser than 20 years of age and only one old woman from the senior citizen group.

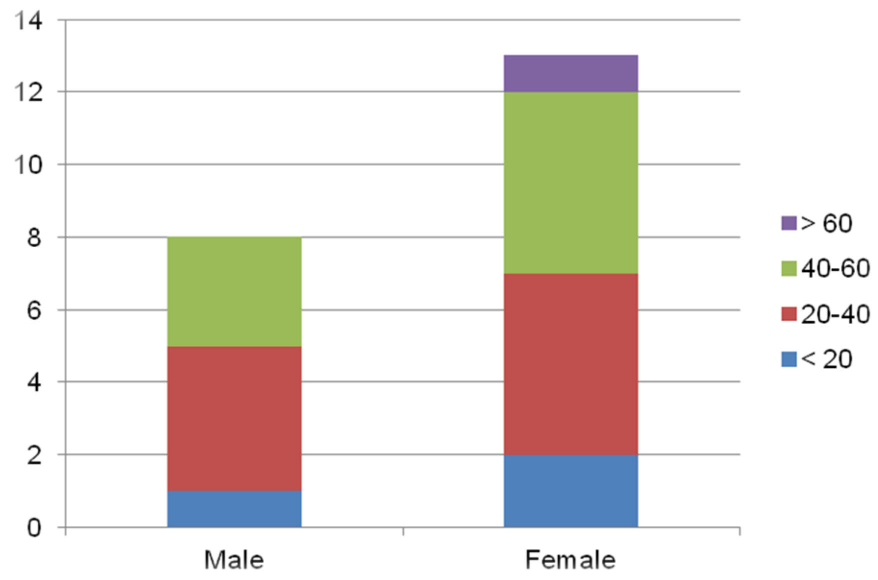


(Fig 7.6) Pie chart showing percentages of male and female



(Fig 7.7) Pie chart showing percentages of age groups

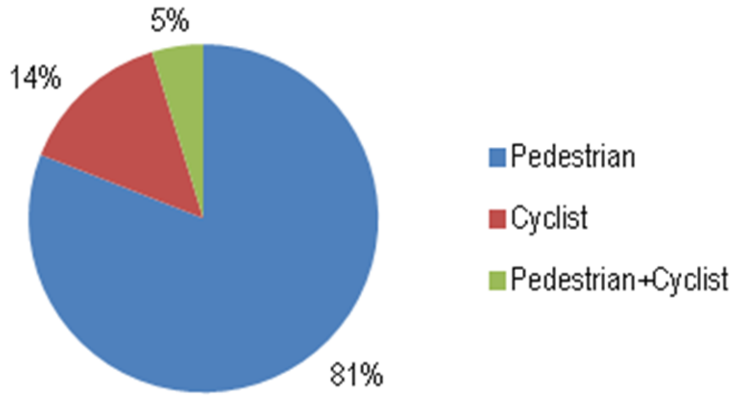
Out of the men interviewed (8 in number), there was just one user (13%) in the age group of under 20, 49% were in the age group of 20-40, and the remaining 38% were in the age group of 40- 60. The female population dominated in participation this time, comprising of 13 users. 16% of the participation was from the youngest age group of less than 20 years, followed equally by 38% in the younger age group of 20-40 and middle aged group of 40-60. There was only one old woman participant in this scenario, making it 8% in the age group of above 60 (Fig 7.8).



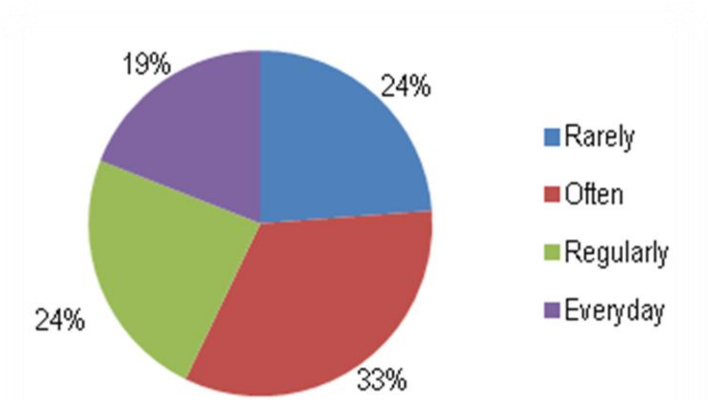
(Fig 7.8) Bar graph showing percentages of gender vs age groups

Q. 3 and 4.How often do you use this road and how? As a pedestrian or as a bicyclist?

Results - The graph (Fig 7.9) below shows the percentages of different kind of users, i.e., pedestrians, bicyclists and people who use the road for both (As a pedestrian as well as bicycling). (Fig 8.0) shows the frequency of the users in the space.



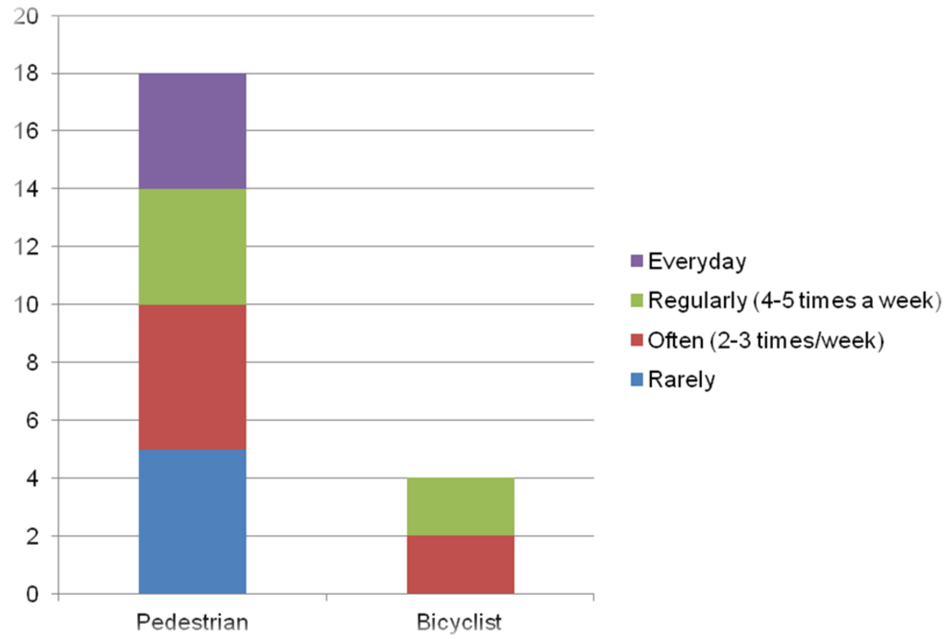
(Fig 7.9) Pie chart showing percentages of mode of users



(Fig 8.0) Pie chart showing percentages of frequency of users

Out of the pedestrians, who formed the majority of the users, 28% used the road rarely and often, 22% used it regularly and daily. This time there was an even distribution in the frequency of people using the road.

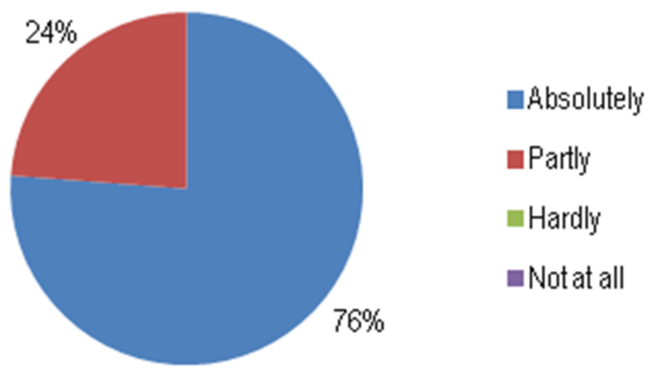
Counting the bicyclists, who were 4 in number, half of them (50%), took this road often where as the other half took it regularly. (Fig 8.1)



(Fig 8.1) Bar graph showing mode of transport and frequency of users

Q5.Do you feel safe while walking on this road?

Results – Yet again, there were just two kind of responses similar to the previous scenario. As it can be seen, around three- fourths (76%) of the people interviewed felt absolutely safe on the road with no threat at all while the remaining one- fourth (24%) were a little skeptical and said they felt partly safe. (Fig 8.2)

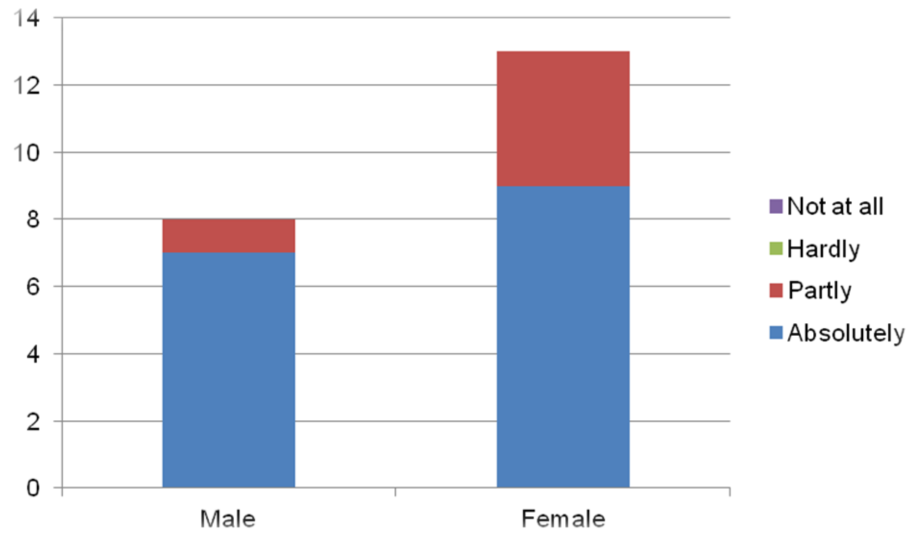


(Fig 8.2) Pie chart showing percentage of safety

Safety versus Gender

Out of all the men(8 in number) who answered, 88% felt absolutely safe, and only 12% (1 person) felt partly safe. Examining the data for the female population, 70% among the interviewed people felt absolutely safe, where as the rest 30%, felt partly safe. (Fig 8.3)

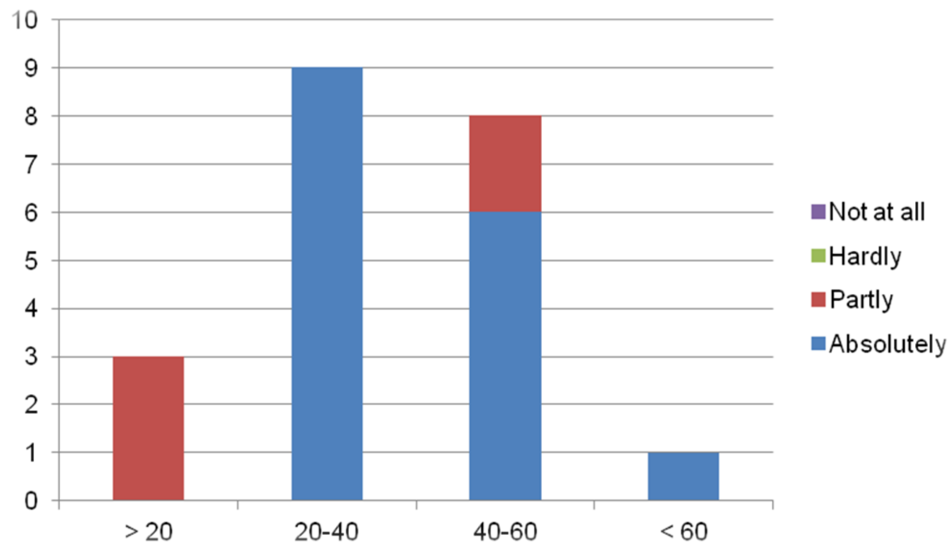
Observations – The figures didn't vary much from the earlier scenario, making it a fair one in terms of feeling safe. Again, of the genders felt any less than 'partly safe', and the ones who felt partly safe were lesser in number than the ones who felt absolutely safe.



(Fig 8.3) Bar graph showing safety vs gender

Safety versus Age group

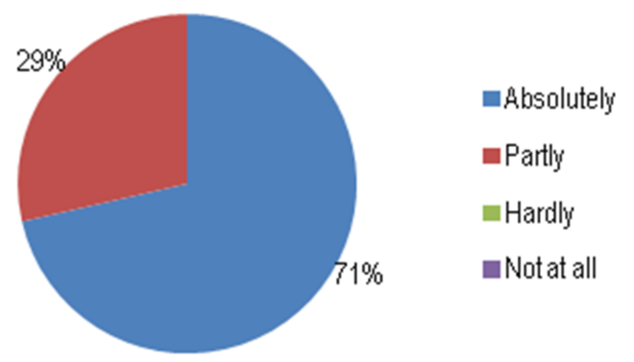
There was an interesting inference from this data. All the men and women who felt safe, majority of them fell into the age group of 20-40.This time there were 3 participants under the age of 20, and all of them felt partly safe in the environment. The users from this particular age-group were somehow consistent in their responses and always felt partly safe, but never absolutely. Studying the bar-graph, it is evident that people from the rest of the age groups, mostly feel absolutely safe except for a few percentage of people from 40-60 feeling partly safe. Considering the younger group of 20-40, 100% felt absolutely safe in the space. Among the middle aged group of 40-60, 73% agreed to find themselves absolutely safe in the space while 27% felt partly safe. Also, the only old person in the whole group seemed to feel absolutely secure in the space. (Fig 8.4)



(Fig 8.4) Bar graph showing safety vs age group

Q6. Is the light here enough for what you need to see?

Results – It was 71% of people responding to be totally satisfied with the quality of light and comfortability required for their vision. However, 29% said that it was partly good for visual clarity. So overall, the response was satisfactory but not as good as the previous scenario #2 even if the previous scenario had lower light level of 8 than the current scenario's light level - 10. (Fig 8.5)

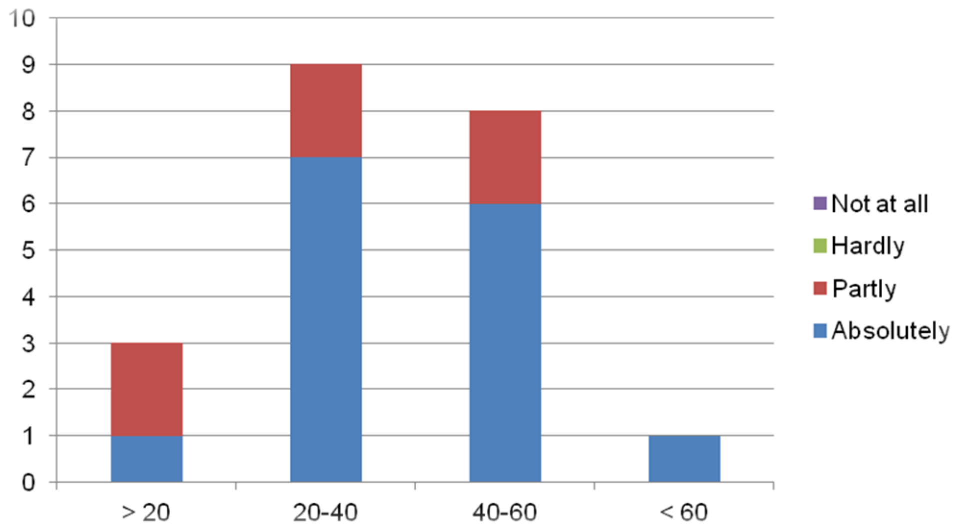


(Fig 8.5) Pie chart showing visul acomfortability in percentages

Visual comfortability versus Age group

In the youngest age group of under 20, 1 out 3 users was absolutely satisfied with the light in terms of visual comfortability, where as 2 of them believed that it was partly good. 78% from the younger age group of 20-40 seemed to feel absolutely good about the light in terms of visual clarity and 22% felt it was partly good. In the age group of 40-60, the percentage of people who chose the 'absolutely' option was 75% and the old woman of 60+ voted it to be the perfect light for her to visually see in the space. (Fig 8.6)

Observations – Overall, majority of the users feel the light quality to be visually comfortable, although some of them find the light to be partly enough to see things clearly. None of the people were completely unsatisfied with the light and vision. Similar to the case of safety vs age group, the people from the group of 40-60 and above 60 had completely same responses about the comfortability in the light as they had about light and safety.

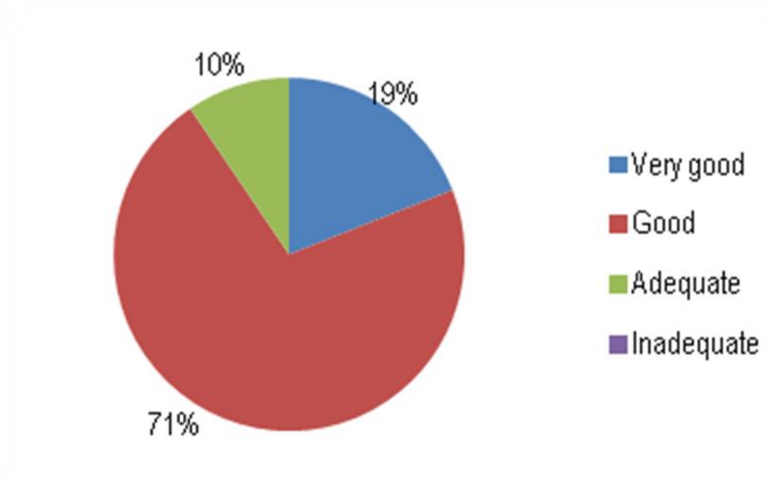


(Fig 8.6) Bar graphs showing visul acomfortability vs age group

Q7. How do you judge the lighting situation?

Results – 19% of the people thought that the light was very good along with the whole atmosphere. 71% believed that the light situation was good if not perfect, and 10% felt that it was adequate. There were few positive changes in the statistical results compared to the scenario#2 (light level-8). Majority of the people believed that the light was good, followed by people finding it very good and only 10% (1 person) finding it to be just adequate. (Fig 8.7)

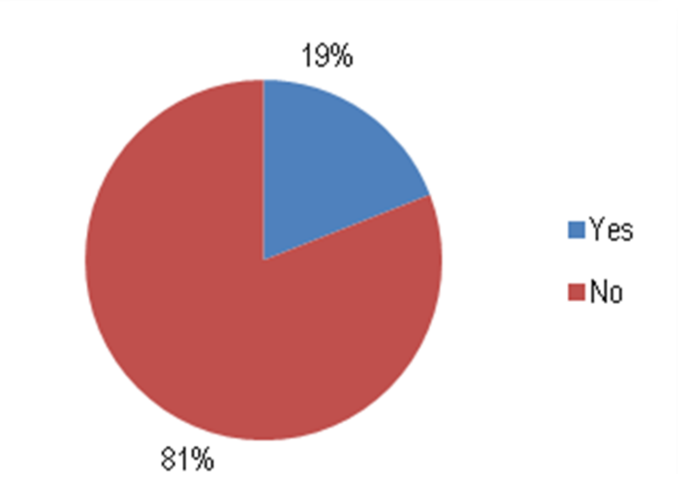
Observations – The satisfaction levels were better than the earlier scenario of #2 (light level – 8), may be higher light levels (level – 10) in this scenario made the difference. Also none of them thought the light to be inadequate.



(Fig 8.7) Pie charts showing responses towards lighting situation in percentages

Q8. Did you notice the new lighting situation in the area?

Results – 81% of the people had not noticed any change in the lighting situation; while 19% said they are aware of it. Out of the 19%, most of them, like before, had witnessed other people taking the survey or had participated earlier. (Fig 8.8)



(Fig 8.8) Pie charts showing responses towards noticing of new lighting installaltion in percentages

Responses and suggestions from people:

Summary of the comments

1. Lighting levels and distribution – Very satisfied with the light quality, the people found it to be ‘good and comfortable light’. There were two lighting design students as participants in this scenario and the comments were very useful. One of them found the light to be comfortable (considering the amount and colour) and the perception of light between the varying high and low levels, i.e. the transition from low to high levels and vice versa was comfortable in the perspective, although she felt that the distribution of the light on the road could be improved to avoid darker regions at some places between the light poles.

2. Safety – All of the participants who commented about the safety aspect were female. One of them found the area to be very safe, whereas the other pointed out to a very interesting fact. She explained that the perception of safety varies noticeably depending on the cultural backgrounds people come from and gender. One of the other respondents found the area behind the trees to be dark and scary, whereas another female said she was aware of the fact that the people hiding behind the trees are homeless people and they are just taking shelter there. Being aware of this fact, it doesn’t scare her irrespective of the presence/absence of surrounding light in the trees.

3. Overall atmosphere and feelings - Majority of the people answered that they feel good in the space, with some of them suggesting scope for improvement in terms of ambience. They felt that since it is a beautiful stretch along the water side, the place could be made livelier in terms of lighting so that people could use the space for social and recreational activities more rather than just using as a walkway or a path for jogging.

4. Colour of light - Only one person (lighting design student) commented about this topic and expressed that the colour of the light (source) is good, and it didn’t change the perception of colours of the surroundings unlike when under sodium vapour (orange/yellow) lamps.

5. General – The most important and impressive comment from a user was – “*Light can change the people, make them good or nasty. It depends on how one designs it.”* It was good to know that people do consider light as an element which can change the behaviour of the people. Others, like before, were supportive of the idea of energy saving and felt responsible to be friendly towards the environment.

SCENARIO # 4

The conditions for the scenario # 4

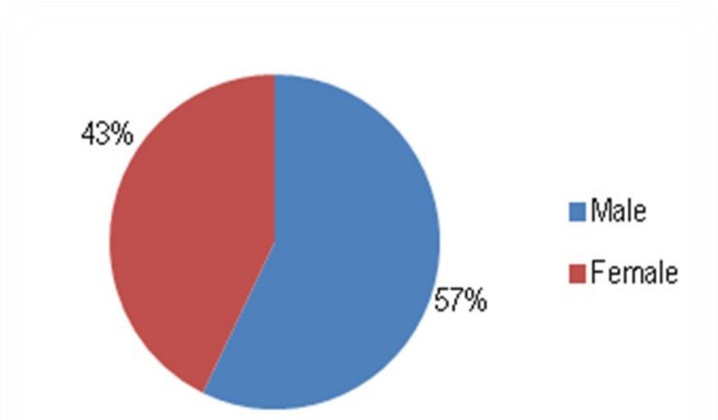
The scenario marked in lime colour in the following chart shows the conditions for this scenario.

Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*--*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

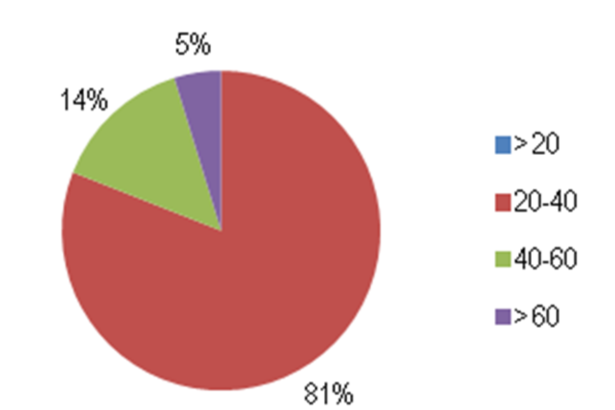
(Fig 8.9) Table showing conditions marked for scenario #4

Results from questions 1 and 2 - Age groups and Gender

The graph (Fig 9.0) below shows the percentages of men and women and (Fig 9.1) indicates the distribution of age groups of participants in percentages. The ratio of men to women was balanced when compared to all the other scenarios. The age group of 20-40 clearly formed a big majority of the participants by 81%, like in most of the cases. The age group of 40-60, made up to 14% of the participants followed by 5% (only one) from the group of above 60.

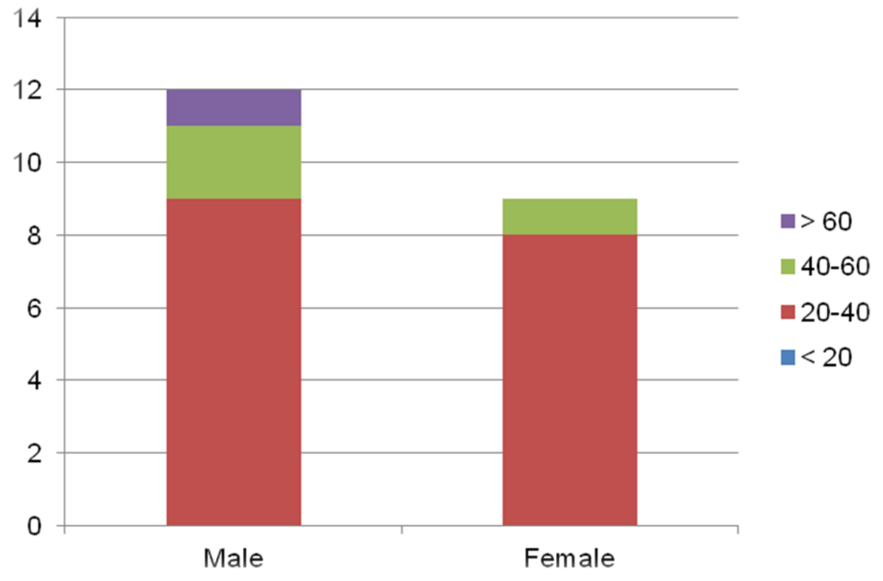


(Fig 9.0) Pie charts showing percentages of male and female



(Fig 9.1) Pie charts showing percentages of age groups

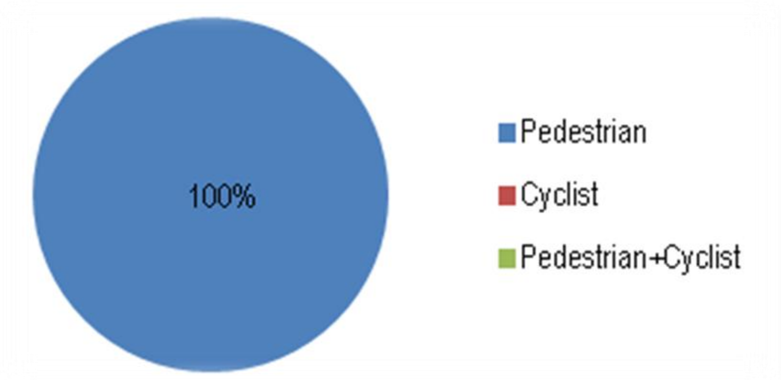
There were no participants from the age group of under 20 for this scenario. Out of the men interviewed (12 in number),75% were in the age group of 20-40, 17% were in the age group of 40-60 and only 1 person which constituted of small 8% of the people interviewed, was from the group of < 60. The ratio of men is to women was quite balanced for this scenario as compared to the previous ones. Coming to the women, (9 in number), most of them, (88%) were a part of younger age group of 20-40, and 1 female user was in the age group of 40-60. (Fig 9.2)



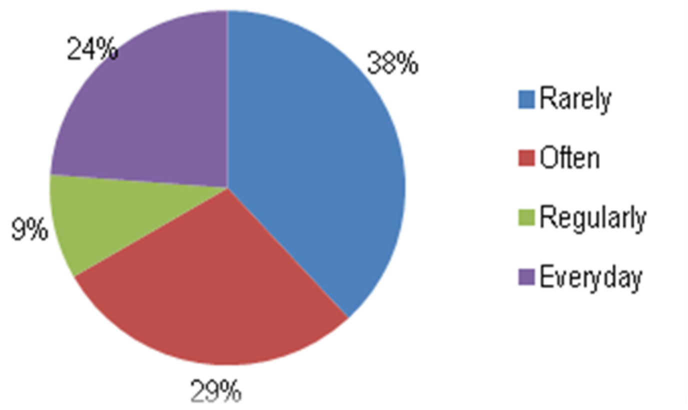
(Fig 9.2) Bar graphs showing percentages of age groups

Q. 3 and 4.How often do you use this road and how? As a pedestrian or as a bicyclist?

Results- The graph (Fig 9.3) below depicts the percentages of different kind of users, i.e., pedestrians, bicyclists and people who use the road for both (As a pedestrian as well as bicycling), but it is apparent that there were no other participants except for the pedestrians in this scenario. (Fig 9.4) shows the frequency of the users in the space.

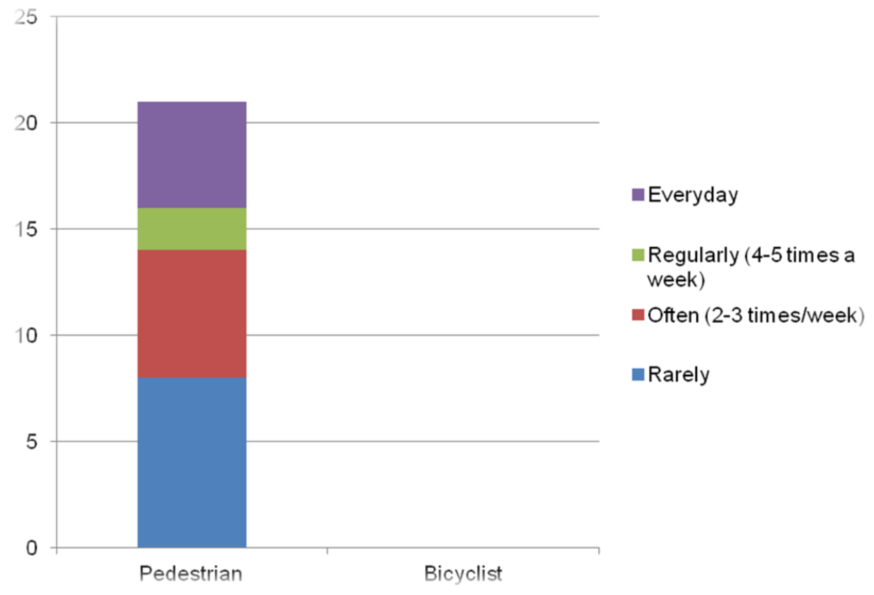


(Fig 9.3) Pie charts showing percentages of mode of users



(Fig 9.4) Pie charts showing percentages of frequency of users

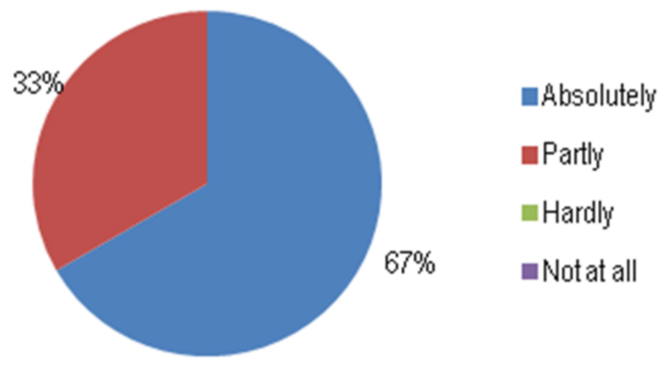
Among the only users, i.e. pedestrians, 38%, 29%, 9% and 24% used the route rarely, often, regularly and daily respectively. (Fig 9.5)



(Fig 9.5) Bar graphs showing mode of transport and frequency of users

Q5.Do you feel safe while walking on this road?

Results – Evidently again, the responses were just based on 'absolutely' and 'partly' options, and none on 'hardly' and 'not at all' options. From the pie- chart, 67% of the people interviewed felt absolutely safe on the road while the remaining 33% were a little skeptical and said they felt partly safe. (Fig 9.6)

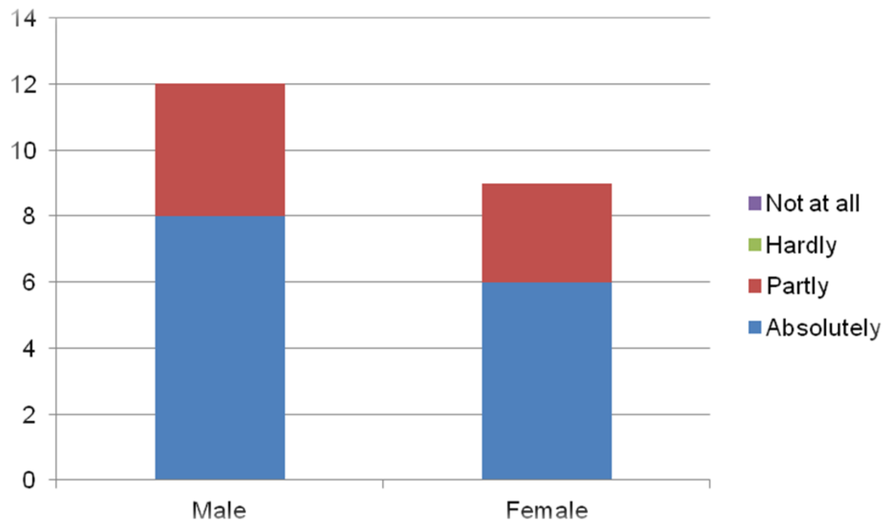


(Fig 9.6) Pie charts showing percentages of safety

Safety versus Gender

Among all the men (12 in number) who polled, 67% felt absolutely safe, and 33% felt partly safe. From the graph the percentages of men and women regarding the perception of safety was coincidentally, the exact same. 67% of women who were interviewed also felt absolutely safe, where as the rest 33%, felt partly safe. (Fig 9.7)

Observations – The results were quite positive. As the percentages of men and women about the perception of safety were the same, it indicates a good satisfaction level among both the genders in this scenario. Also, none of them went below the idea of partial safeness, which was also a positive outcome.

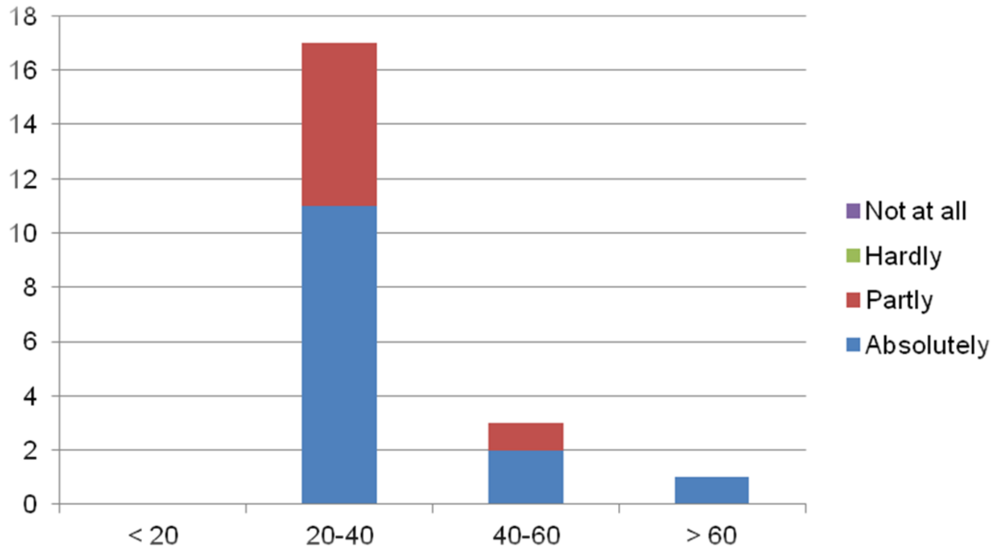


(Fig 9.7) Bar graphs showing safety vs gender

Safety versus Age group

Unfortunately, there were no participants from the youngest age group, though from the younger group of 20-40, 65% felt absolutely safe, followed by 35% of partial safeness. The middle aged group of 40-60, had similar kind of responses as the group of 20-40; 67% felt absolutely safe and 33% felt partially safe. The only old man seemed to feel absolutely secure in the space. The point to be noted is the older generation always seem to feel very secure and assured in the environment as compared to the other age groups with varying reactions for each scenario.(Fig 9.8)

Observations - The results in this case were satisfactory, with a lesser percentage of people from 20-40 and 40-60 age group feeling partly safe, although there was just one participant from the senior age group. The point to be noted is the older generation always seem to feel very secure and assured in the environment as compared to the other age

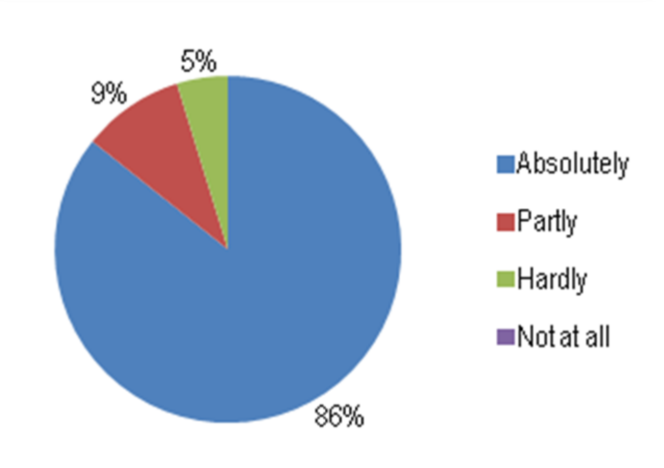


(Fig 9.8) Bar graphs showing safety vs age groups

groups with varying reactions for each scenario.

Q6. Is the light here enough for what you need to see?

Results – 86% of people responded to be totally satisfied with the quality of light and comfortability required for their vision while moving around the site. However, 9% said that it was partly good and 5% (1 person) said it was just adequate for visual clarity. Overall, responses were overwhelming with a big majority finding the light absolutely good. (Fig 9.9)

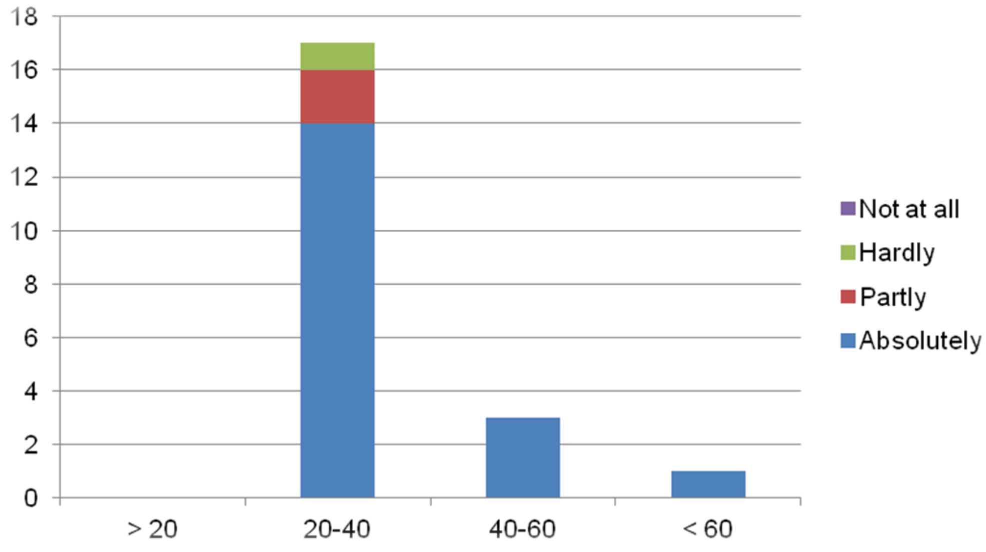


(Fig 9.9) Pie charts showing responses towards visual comfortability in percentages

Visual comfortability versus Age group

82% from the younger age group of 20-40 seemed to feel absolutely good about the light in terms of visual clarity, the next 10% going with the 'partly' good light and the remaining 8%(1 person) responded that the light was hardly enough. In the age group of 40-60 and 60+, everybody felt that it was perfectly good enough. (Fig 10.0)

Observations – Overall, majority of the users feel the light quality to be absolutely visually comfortable, although a very short percentage of them find the light to be partly enough (2 people) and 1 person found it hardly enough to see things clearly. None of the people were completely unsatisfied with the light and vision. So the situation suggests to be satisfactory and comfortable visually, the limitations being there were no participants from the age group of under 20 years of age.

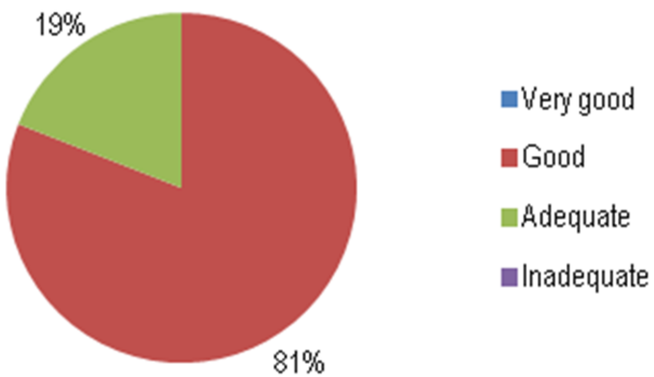


(Fig 10.0) Bar graphs showing visual comfortability vs age groups

Q7. How do you judge the lighting situation?

Results – 19% of the people thought that the light was adequate in the whole atmosphere and 81% believed that the light situation was good.

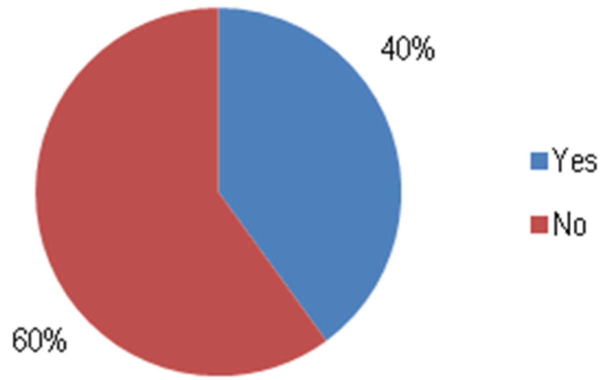
Observations – The responses this time were quite different from the earlier scenarios. Although people were satisfied with the safety and visual comfortability aspects of the light to a good extent, none of them felt that the overall lighting situation was very good unlike the previous scenarios. Also, apart from 81% the people who felt it was good, there were 19% of them who felt it was just adequate. The answers of the people during this scenario regarding the perception of lighting situation were not as good as the previous scenarios. (Fig 10.1)



(Fig 10.1) Pie charts showing response towards lighting situation in percentages

Q8. Did you notice the new lighting situation in the area?

Results – 60% of the people had not noticed any change in the lighting situation; while 40% said they are aware of it, which was a good increase regarding the awareness of change in lighting on the site. But out of the 40%, most of them, like before, had witnessed other people taking the survey or had participated earlier. (Fig 10.2)



(Fig 10.2) Pie chart showing response towards noticing of new lighting installation in percenatges

Responses and suggestions from people:

Summary of the comments

1. Lighting levels and distribution – Though the overall reaction to the lighting situation was good like in the previous cases, but two of them distinctly pointed out the problem with their point of view. Both of them suggested that the distance between two adjacent poles were not uniform everywhere, especially the poles closer to the Tekniska Namndhuset building are placed far apart giving an impression of low light levels than required. Some of them responded that the lights look 'bright and powerful' whereas one of them liked the place with dimmed light levels when there were no people walking around, avoiding unnecessary light for the residents living around. Another user expressed that during last few days, he subconsciously sensed some change in the ambience of the place and thought it was much better and brighter, although the idea of any change in the light fixtures didn't occur to him. Another person said that the transition from the low to high light levels and vice versa was gradual and was not clearly noticeable, hence making it visually comfortable.

2. Safety – Similar to the previous cases, it was only the women who expressed any comments about the safety in the place. Two of them agreed that it feels very safe in the place during the busy hours, but the situation could be completely different when there were no people in the place. There was a slight doubt in their minds about the feeling of safety during late hours. There was only one person till now among all the scenarios, who didn't like the idea of changing light levels at all was a woman in her late twenties.She admitted that it was so because she is a girl and feels extremely vulnerable. On the contrary, another woman said that it feels completely safe to walk along the stretch with the presence control systems, even if it was late in the night.

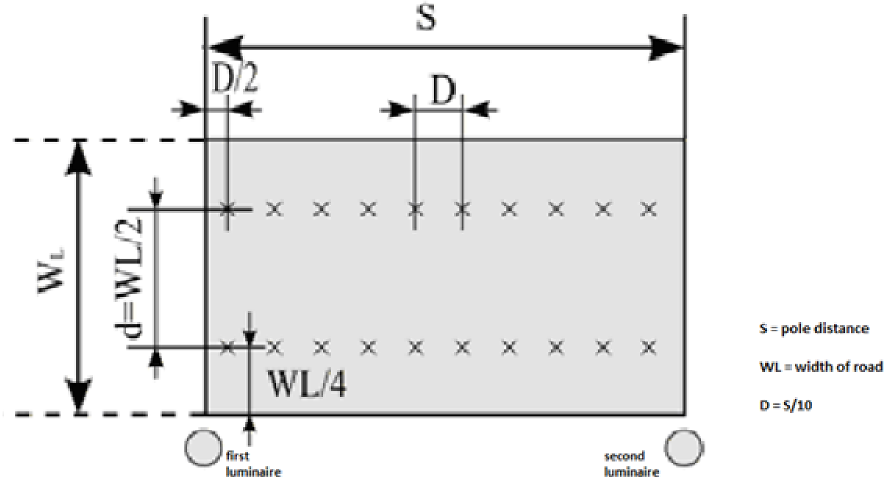
3. Overall atmosphere and feelings – Feeling good in the space was now an obvious answer although one elderly man was very content with the lighting.

4. General – The general public seem to embrace the idea of energy saving with lighting control system very positively; one of them suggested that it was a good initiative towards preventing light pollution too. The participants who had participated in the earlier scenarios also mentioned that they didn't find any difference among the scenarios and find it good. A lighting design student felt that this scenario works better with the idea of lesser timer settings, as it is probably more efficient in terms of energy without compromising on the users comfort.

5.1.b. LUX LEVELS

The lux levels were measured with few reference points with the help of a luxmeter (name-Hagner, Screen Master; made in Sweden; Instrument no. 30516 CE) and isolux diagrams were produced with the help of a software (Surfer 8.0) in order to see the distribution of light on the horizontal surface of the road.

"The longitudinal road surface area for calculation is taken from the first luminaire to the following one on the same side of the road. The transverse road surface area for calculation is defined by the borders of the road. As shown in the below figure there should be two grid lines per lane located on quarter (1/4) of the distance from the edge of each lane. In the longitudinal direction the distance between grid lines shall be one tenth (1/10) of the spacing between luminaires, or 5 meters, whichever is smaller. The starting point for grid lanes should not be located directly under the luminaire, but the grid should start at a point one half (1/2) of the grid cell size from the luminaire." [1]



(Fig 10.3) Target location orientation diagram, IESNA [2005]

On the examined part of the road, the distance between two consecutive light poles is not the same everywhere but varies. It is 15.5 metres between the chosen first and second pole where as its 17.5 metres between the second and third pole. The width of the road is 4 metres. In order to create the measurement grid according to the IESNA regulations, the following is the required data:

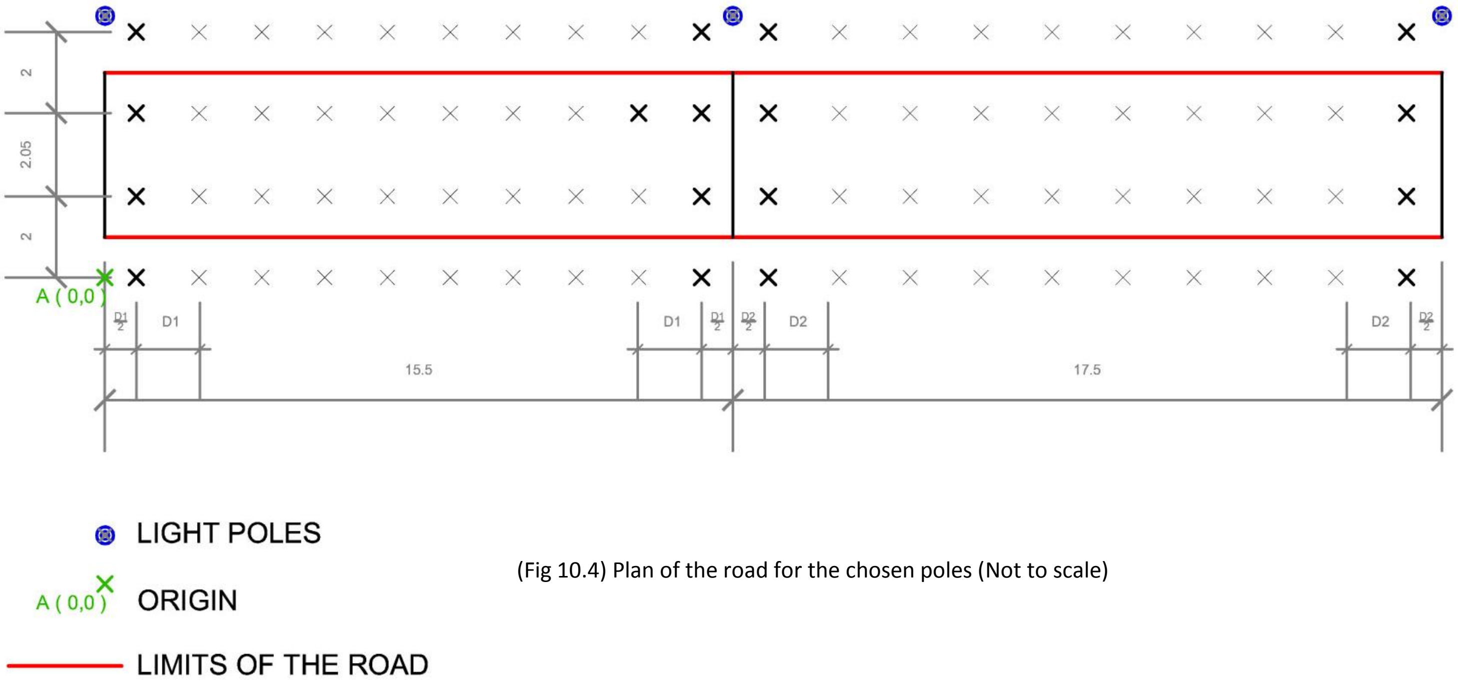
S_1=15.5m, W_L=4m, D=S_1/10=15.5/10=1.55m.

Similarly for the measurements required for the distance between second and third pole were as follows:

S_2=17.5m, W_L=4m, D=S_2/10=17.5/10=1.75m

[1] http://lib.tkk.fi/Diss/2010/isbn9789526030838/article1.pdf

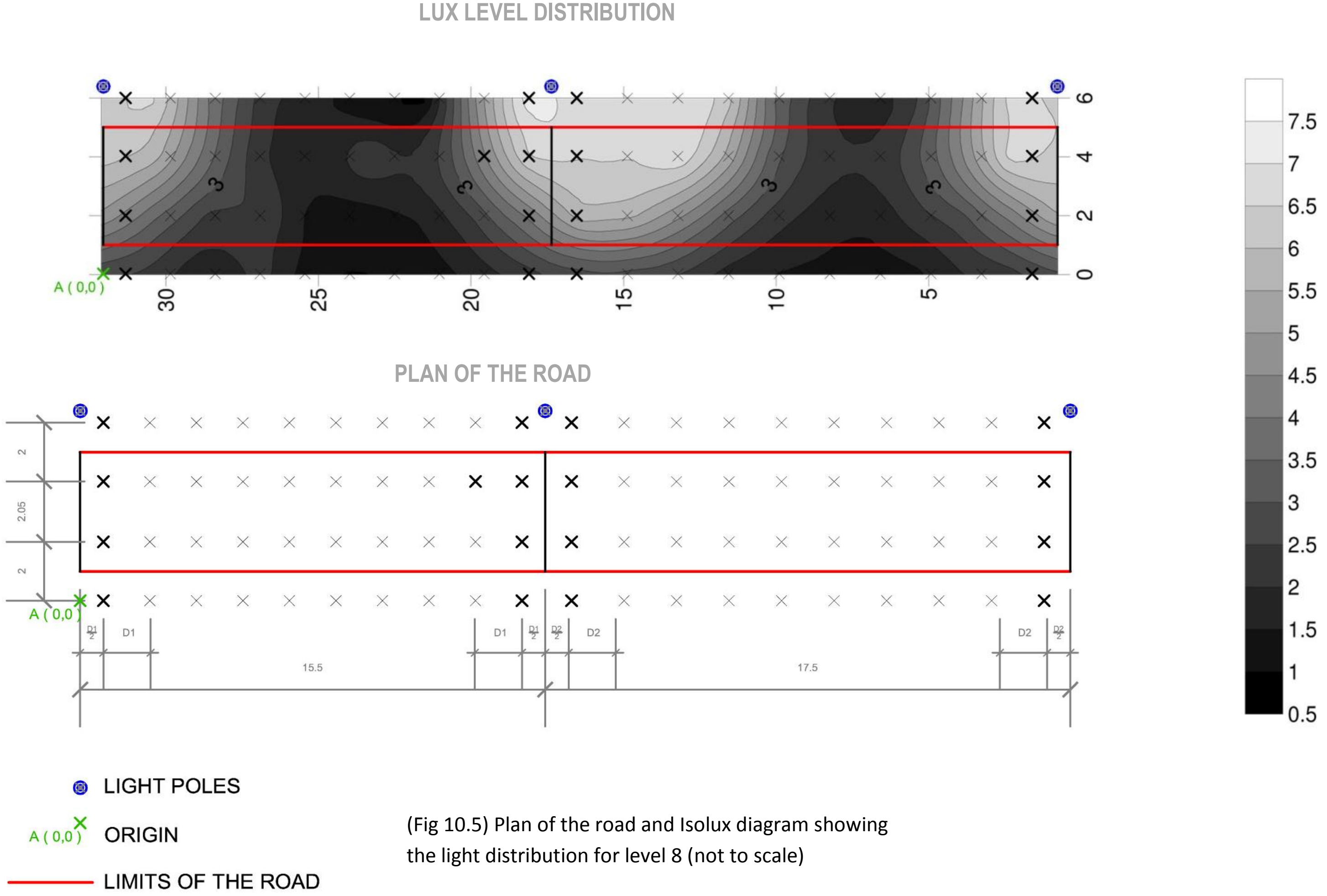
The following drawing shows the plan of the road surface which was the field of measurement for the lux readings. The plan shows the 1st, 2nd and 3rd poles, distances between them and the origin A(0,0).



(Fig 10.4) Plan of the road for the chosen poles (Not to scale)

It was better to take readings for two fields of measurements in order to have a better view for the results. Hence, measurements were taken between three consecutive light poles. Readings were also noted down outside a range of 1 m from the border of the road in order to get a better picture in terms of distribution of light into the surroundings. A reference point A (0, 0) was marked as the origin in order to take the measurements correctly and process it. All the measurements were taken late in the evening to avoid any skylight.

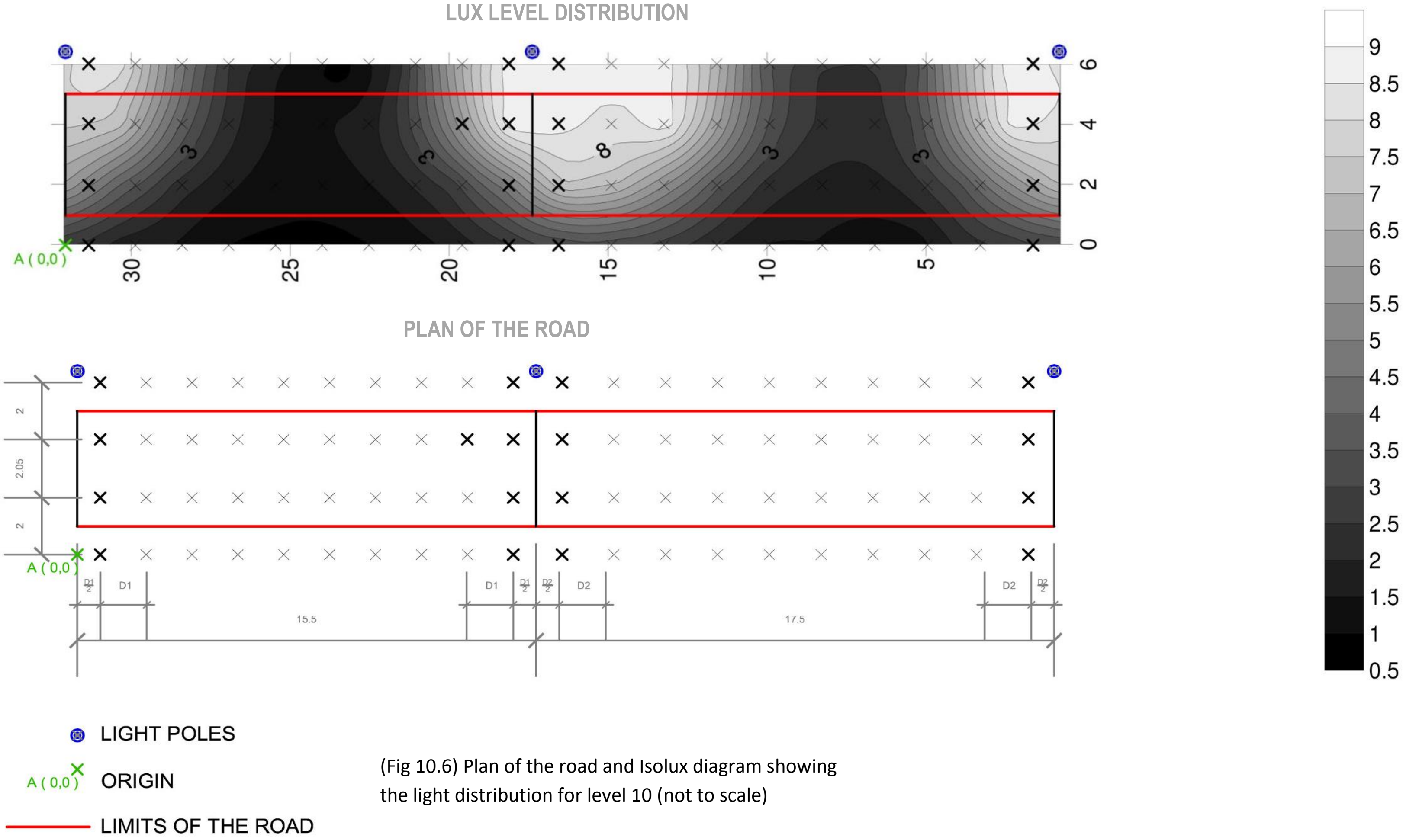
ISOLUX DIAGRAM FOR LEVEL 8



(Fig 10.5) Plan of the road and Isolux diagram showing the light distribution for level 8 (not to scale)

Observations - As we can see from the isolux diagram for light level – 8 (Fig 10.5), the light distribution is quite good without strong contrast between the highest and lowest light level on the surface of the road. The light fades out gradually in circles without forming strong, concentrated areas /spots of light.

ISOLUX DIAGRAM FOR LEVEL 10



(Fig 10.6) Plan of the road and Isolux diagram showing the light distribution for level 10 (not to scale)

Observations - As we can see from the isolux diagram for light level – 10 (Fig 10.6), the light distribution is quite the same from that of level 8, but with different intensities. The contrast between the highest and lowest light level on the surface of the road is higher than that in the case of level - 8. Here also, the light fades out gradually in circles but as seen from the diagram, in the centre of the stretch (centre pole), the light is highly concentrated like a spot light. This difference as compared to the earlier situation is obviously due to the stronger intensity of light.

(Fig 10.7) View of the site installation

5.1.c. LUMINANCE DATA

The luminance data* is one of the ways to understand the lighting condition in any given situation or environment. Here, the aim was to capture photographs and then understand the perception of the lighting from the human perspective in the space and analyse if the lighting installation was working good with the human vision and human point of view while entering or walking along the whole installation.

* Data from Effrosyni Stragali

A number of photographs were taken along the installation stretch from different viewpoints. The photographs were taken during different scenarios; one with maximum light level at 10, one with maximum light level at 8 and with light level of 5 as minimum and level 10 as maximum in order to be compared.

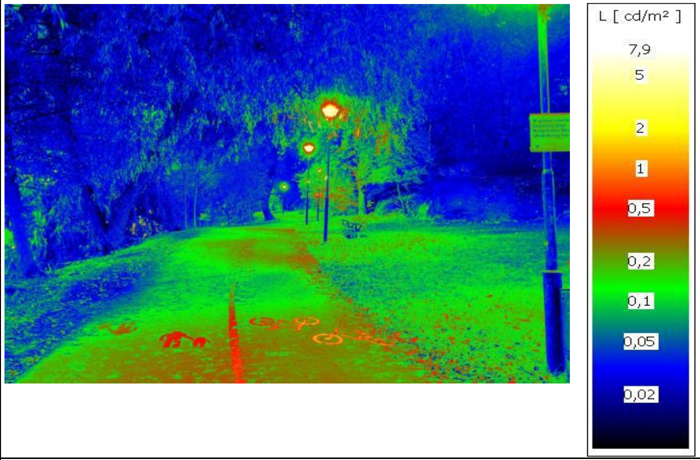
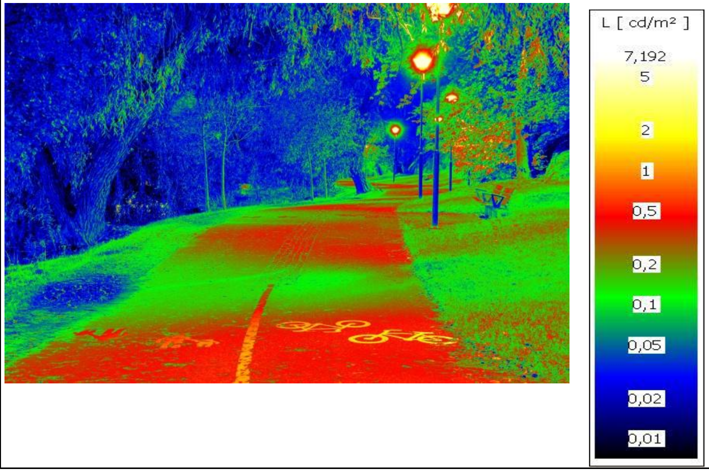
The comparisons are done in terms of visual evaluation as well as luminance levels. The luminance pictures are processed with the help of a software (LMK LabSoft software by TechnoTeam Bildverarbeitung GmbH) and the colour scale shows the luminance values in the processed pictures. This analysis is done to see if the perception of the space varies considerably with changing light levels or is the difference negligible.

(Fig 10.8) Gooogle map of Kungs holms strand site stretch with showing marked views for luminance data

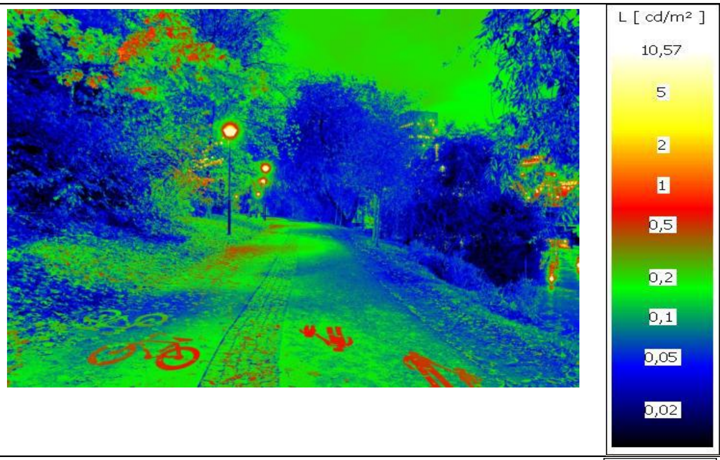
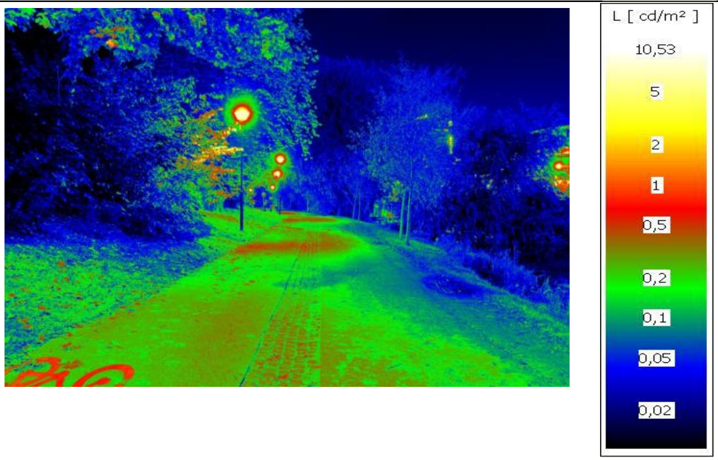
VIEW POINTS

Along the stretch of approximately 750 metres, certain positions were decided as reference points in order to capture the photographs for the evaluation of the luminance data. In the map in (Fig. 13.3), the points marked in purple colour show the stations/ positions from which the photographs were captured and the dotted lines depict the direction of the views for the photographs taken for the luminance data evaluation.

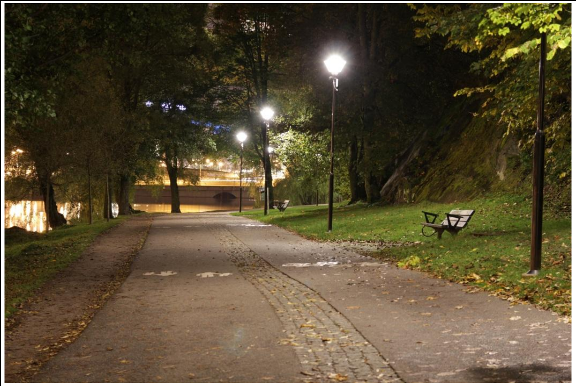
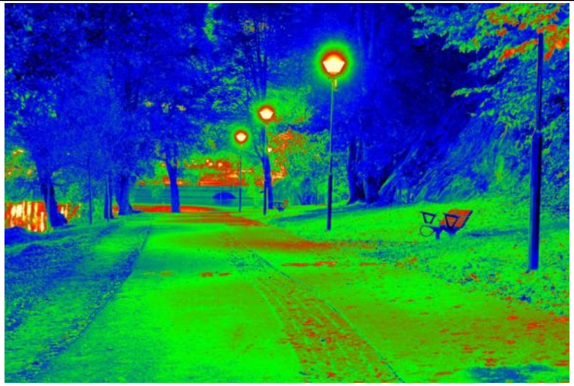
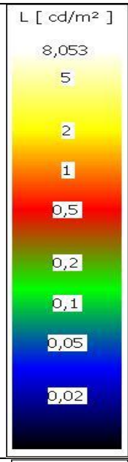
VIEW 1

PHOTOGRAPH	LUMINANCE PICTURE WITH COLOUR SCALE	OBSERVATIONS
 MAXIMUM LIGHT LEVEL - 8	 	• When comparing the photographs, the light levels seem to be balanced and not very bright in case of the view with maximum light level 8 than that with light level of 10, where they are perceived to be brighter. • The light distribution on the road in the former photograph is more uniform than that with maximum light level of 10, i.e., not much distinguished difference between lighter and darker regions with maximum light level 8 compared to that of level 10. This is apparent from the luminance pictures and the colour scale. In light level 8, the uniformity is higher as most of the colours are from the same band (greenish) in the scale, where as in light level 10, we can see distinguished consecutive red and green colours on the road indicating stronger contrast and lesser uniformity.
 MAXIMUM LIGHT LEVEL - 10	 	

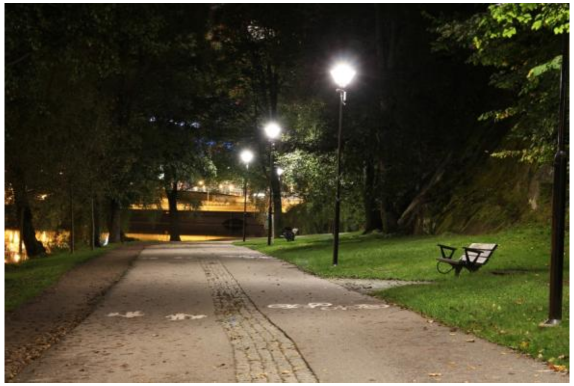
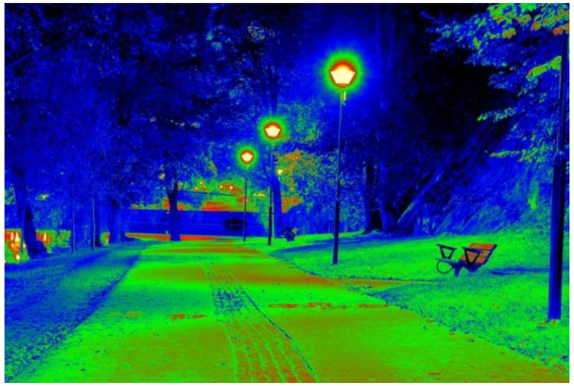
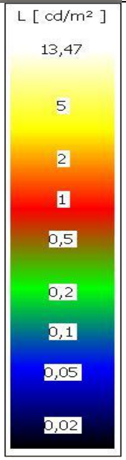
VIEW 2

PHOTOGRAPH	LUMINANCE PICTURE WITH COLOUR SCALE	OBSERVATIONS
 **MAXIMUM LIGHT LEVEL - 8**	 	• When comparing the photographs, the light levels seem to be balanced in case of the view with maximum light level 8 than that with light level of 10, where they are perceived to be brighter. This comparison is based in terms of distribution of light on the horizontal road surface. • In this case, the light distribution on the road in both the photographs is quite uniform, i.e., not much distinguished difference between lighter and darker regions. This is shown in the luminance pictures and the colour scale, where most of the colours are from the greenish band in the scale and is very similar in both the cases. But it must be noted that the luminance values of light level 10 are slightly higher (more of red colour on the road) than that of level 8 (less of red colour). • The surroundings make a considerable difference while perceiving the whole lighting situation. The two situations give quite same luminance impression, even if in the second case the light levels are higher. This may be due to the fact that level 8 picture has yellower leaves on trees and cloudy sky which have higher reflectance than that in the picture of level 10 with green leaves.
 **MAXIMUM LIGHT LEVEL - 10**	 	

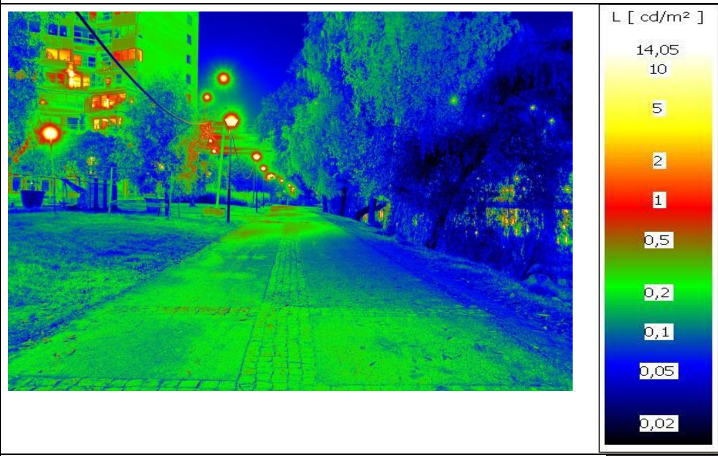
VIEW 3

<table>
<tr><th>PHOTOGRAPH</th><th colspan="2">LUMINANCE PICTURE WITH COLOUR SCALE</th><th>OBSERVATIONS</th></tr>
<tr><td>
MAXIMUM LIGHT LEVEL - 8</td><td></td><td>
</td><td rowspan="2">

- Similar to the earlier cases, when comparing the photographs, the light levels seem to be balanced and not very bright in case of the view with maximum light level 8 than that with light level of 10, where they are perceived to be brighter on the road surface.
- In this case, the light distribution on the road in both the photographs is quite uniform, i.e., not much distinguished difference between lighter and darker regions. This is shown in the luminance pictures and the colour scale, where most of the colours are from the greenish band in the scale and is very similar in both the cases. But it must be noted that the luminance values of light level 10 are considerably higher than that of level 8, the maximum values of which are shown in the colour scale. In spite of this difference in the values, the distribution is similar in both the cases.
- Again, the perception is affected by the surroundings. The photograph with level 8 has yellower leaves on trees which have higher reflectance than that in the photograph of level 10, where the leaves are green. So, the view with light level 8 appears to be of warmer tone than that of level 10.

</td></tr>
<tr><td>
MAXIMUM LIGHT LEVEL - 10</td><td></td><td>
</td></tr>
</table>

VIEW 4

PHOTOGRAPH	LUMINANCE PICTURE WITH COLOUR SCALE	OBSERVATIONS
 MAXIMUM LIGHT LEVEL - 8		• When comparing the photographs, the light levels seem to be balanced and not very bright in case of the view with maximum light level 8 unlike the photograph with light level of 10, where they are perceived to be much brighter. • The light distribution on the road in the former photograph is more uniform than that with maximum light level of 10, i.e., not much distinguished difference between lighter and darker regions with maximum light level 8 compared to that of level 10. This is apparent from the luminance pictures and the colour scale. In light level 8, the uniformity is higher as most of the colours are from the same band (greenish) in the spectrum, where as in light level 10, we can observe bit more of red along with green colours on the road indicating higher contrast and lesser uniformity.
 MAXIMUM LIGHT LEVEL - 10		

COMPARISONS BETWEEN DIMMED BACKGROUND (Light level-5; no presence of user) AND MAXIMUM LIGHT LEVEL (Light level-10; at the current position of the user) 'VS' MAXIMUM LIGHT LEVEL (Level -10 along the whole installation without dimmed background)

This set of comparisons is done to study the maximum differences in terms of light levels (from level 5 to level 10) at the background view of the user. The following questions would be addressed in this section:

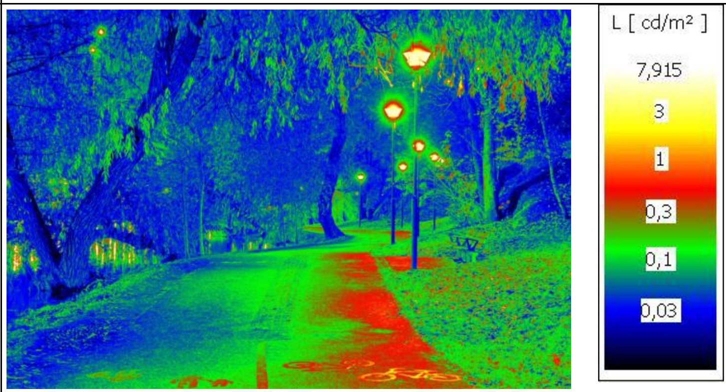
- Does the user perceive the difference in the light levels in perspective while walking along the pathway?
- If yes, does this affect the feeling of safety in the space?

At the position of the photographer and 3 poles in front of the photographer are at level 10 where as beyond those three poles, the light level is at 5 (dimmed situation and no presence of user).

(Fig 10.9) View of the site installation

NOTE: The situation of the surroundings plays an important role in the perception of the space. The former photographs in the rows of pictures in tables showing the installation with level-10 (at current position of the user) and the background dimmed to lowest level-5, were taken during late autumn when there were lesser leaves on the trees and yellow in colour compared to the later photographs in the row, which were taken much earlier while the trees were dense and leaves were greener. The presence/ absence of leaves affect the human field of vision and the perception of safety while the colours of the surroundings vary the reflectance of light and affect the perception of brightness in the space.

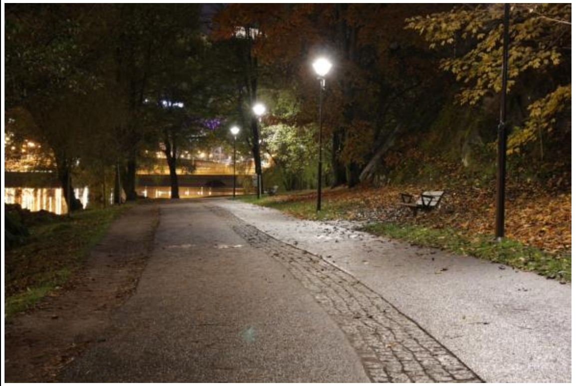
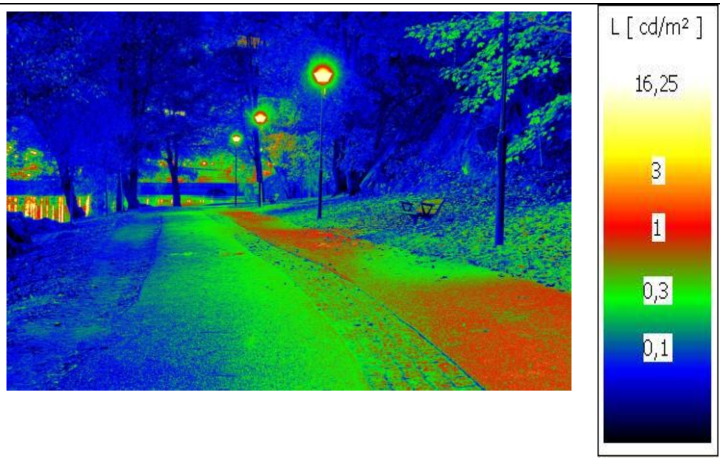
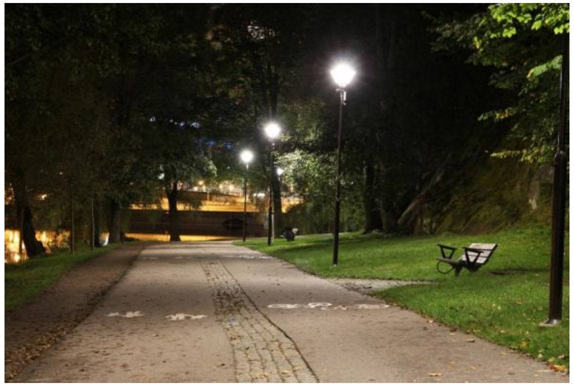
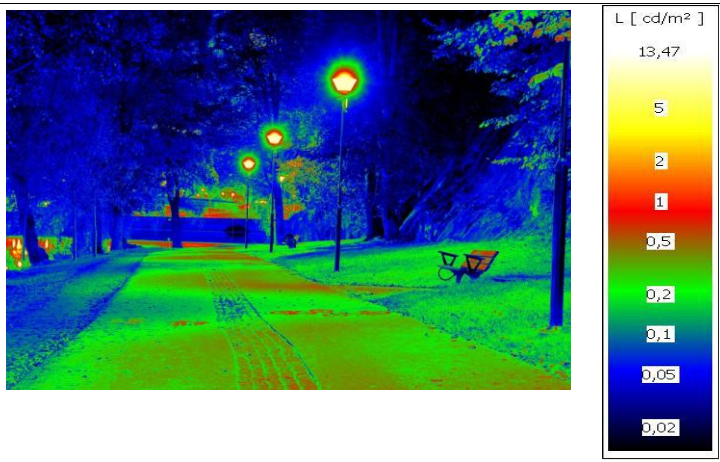
VIEW 1

<table>
<tr><th>PHOTOGRAPH</th><th>LUMINANCE PICTURE WITH COLOUR SCALE</th><th>OBSERVATIONS</th></tr>
<tr><td>
LEVEL – 10 (3 poles ahead of the current position of the user) and LEVEL – 5 to which rest of the installation is dimmed.</td><td>
</td><td rowspan="2">

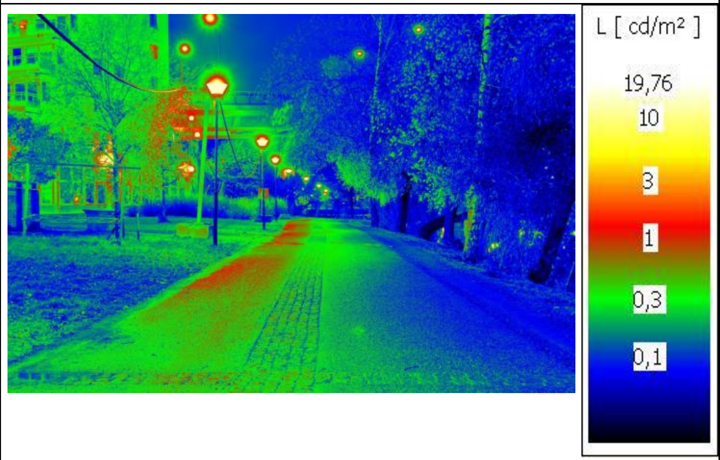
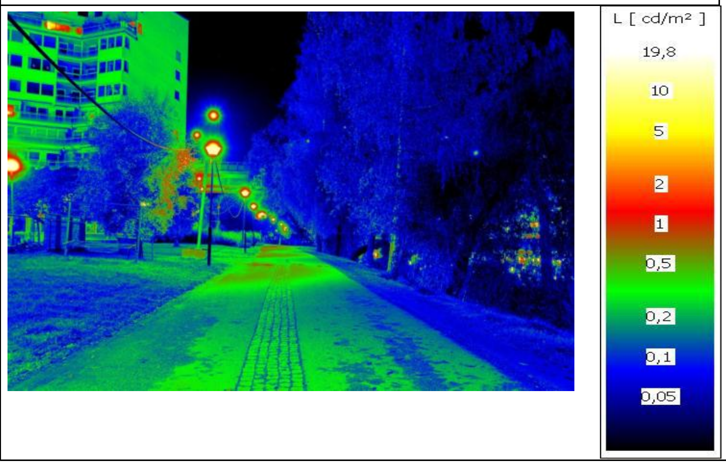
- While analysing both the photographs, we can see that there is a slight difference perceived in this view of perspective between the dimmed background situation and the situation where the whole installation is on maximum level of 10. However, users cannot perceive the difference in the light levels while walking along the stretch. The only difference seen is due to the effect of surroundings and surrounding light in both the photographs. The light in the former photograph appears warmer because of the yellow colours of the leaves and light from the surroundings (due to the absence of leaves from the trees).
- However it must be noted that, in the first case, the values in the colour scale are higher than in the second case and it might be possibly due to the fact that in the former case the weather was rainy and made the road shiny with water; providing it with higher reflectance.

</td></tr>
<tr><td>
LIGHT LEVEL – 10 along the whole installation</td><td>
</td></tr>
</table>

VIEW 3

<table>
<tr><th>PHOTOGRAPH</th><th>LUMINANCE PICTURE WITH COLOUR SCALE</th><th>OBSERVATIONS</th></tr>
<tr><td>
LEVEL – 10 (3 poles ahead of the current position of the user) and LEVEL – 5 to which rest of the installation is dimmed.</td><td>
</td><td rowspan="2">• When comparing both the photographs, one cannot easily perceive the difference between the dimmed light levels in the background and the case where the whole installation is turned on at maximum light level of 10. The surface of the road in the former case is wet because of the rain, and hence the reflectance on the horizontal road surface is higher. There is a probability that since there is interference from the surrounding lights of the city and the neighbourhood, people might not be able to notice the difference between dimmed light levels and higher light levels so distinctly. In case of some situations where the place was isolated and these were the only lights present with dimmed levels in the background and higher levels at the current position, the difference in light levels could have been probably perceived by people.</td></tr>
<tr><td>
LIGHT LEVEL – 10 along the whole installation</td><td>
</td></tr>
</table>

VIEW 4

PHOTOGRAPH	LUMINANCE PICTURE WITH COLOUR SCALE	OBSERVATIONS
 LEVEL – 10 (3 poles ahead of the current position of the user) and LEVEL – 5 to which rest of the installation is dimmed.	 	• In this case also, analysing both the photographs, there is not much difference perceived in this perspective between the dimmed situation and the situation where the whole installation is on maximum level of 10. Users cannot perceive the difference in the light levels while walking along the stretch, although this view shows many more light poles as compared to the earlier view 1. Similar to the view number 1, the only difference observed is due to the effect of surroundings and surrounding light in both the photographs.
 LIGHT LEVEL – 10 along the whole installation	 	

5.2 TECHNICAL EVALUATION

5.2.a. ENERGY CONSUMPTION EVALUATION

The results from the energy consumption values will be depicted in the form of line graphs. The changing power consumption readings were registered for all the scenarios with lighting control systems, i.e. from scenario #1 to scenario #4 for all the days in the respective scenarios. The time of the readings varied usually from 16.00- 4.00 hours every day, though it was 17.00-04.00 hours for scenario #1 and 16.00-05.00hrs (for 3 days out of 5) for scenario #4 respectively.

Predefined light levels were decided in terms of brightness/ light output levels ranging from 'Level- 1' *(lowest light output level)* to 'Level –10' *(highest light output level)* which helped to develop different scenarios with different 'levels' from the standard. The following table shows the different scenarios designed for the lighting installation for comparisons among various aspects.

Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*- NO -*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

(Fig 11.0) Table showing conditions for all scenarios

The data from the graphs in the following section would be helpful in evaluation of information regarding power consumption, peak traffic hours and to make comparisons among different scenarios in terms of power consumption.

NOTE: Times indicated in the readings for all scenarios are in CET time. Scenario #1 to #3 did run during daylight saving time, whereas scenario#4 did run without daylight saving time.

SCENARIO #0

This is the basic scenario with the following conditions:

- No dimming down of lightning without the use of sensor/ control systems.
- Power at level-10 (full power) all the time.

Scenario	Low Power level	High Power level	Number of poles	Timer setting (s)
# 0	10	10	All	-NO-
# 1	5 (7 for first 3)	10	All	120
# 2	5 (7 for first 3)	8	All	120
# 3	5 (7 for first 3)	10	7 (3+1+3)	120
# 4	5 (7 for first 3)	10	7 (3+1+3)	60

(Fig 11.1) Table showing conditions for scenario #0

The net consumption of just the LED lightning poles was measured on 2012-10-04 by disconnecting all other consumers in the circuit. The net consumption was 1035 W (30.5W / pole).

Average total consumption at high power, using mean values for the first days was assumed to be 3795W. This means the power consumption besides the new installation poles are 3795 – 1035 = 2760 W. If subtracting this "besides consumption" value (2760 W) from power measurements below, then we can assume to have net power values for just the light poles.•

• Data from Göran Nordenberg

SCENARIO #1

Duration: 07-10-2012 (Sunday) to 13-10-2012 (Saturday)

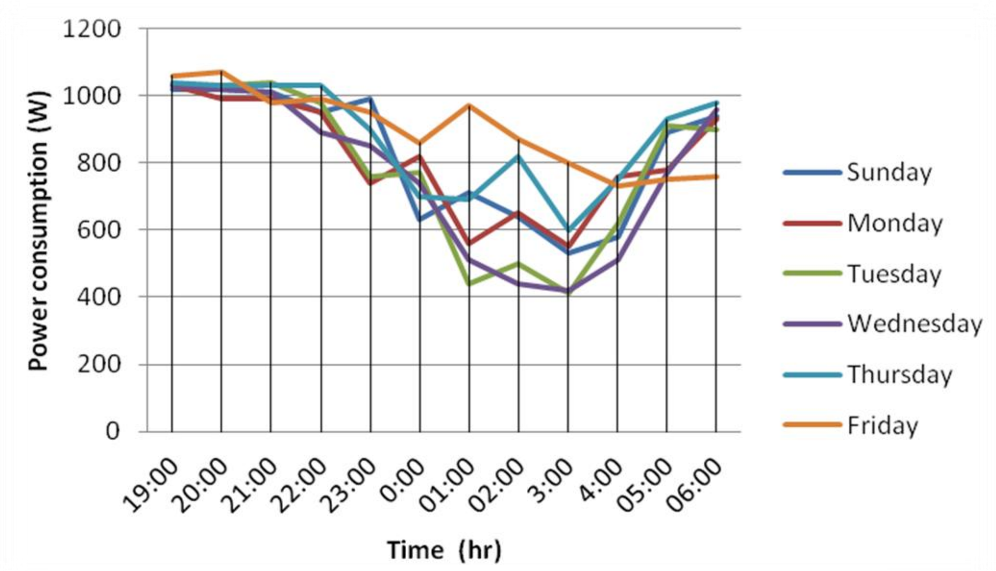
The conditions for the scenario are as follows:

- High power 10 (full power)
- Low power 5 on “mid” poles
- Low power 7 on each 3 poles at the ends
- High power for 120 seconds after activation
- High power on all poles after activation

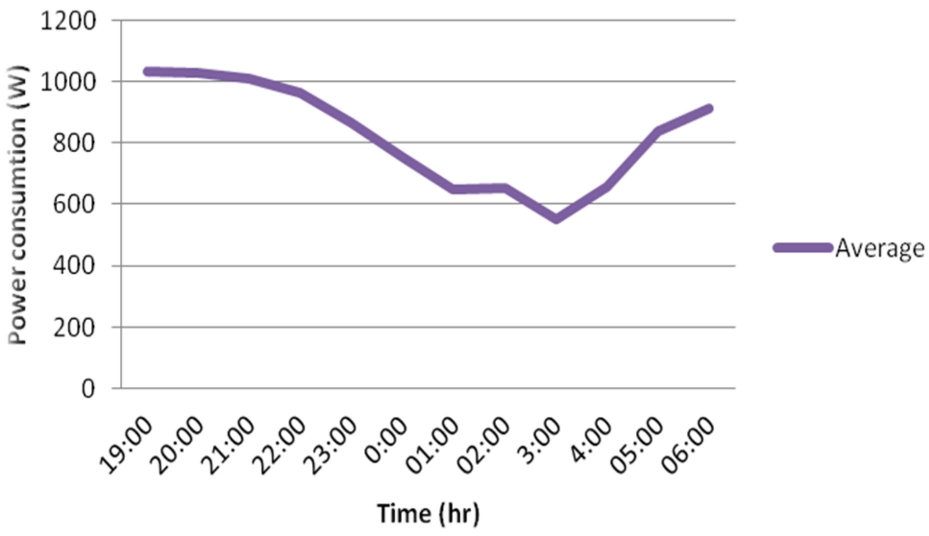
Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*-NO-*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

(Fig 11.2) Table showing conditions for scenario #1

NOTE: One of the end poles had difficulty to reach by radio and used high power (level – 10) all the time.



(Fig 11.3) Line graph showing total power consumption for scenario #1



(Fig 11.4) Line graph showing total average power consumption for scenario #1

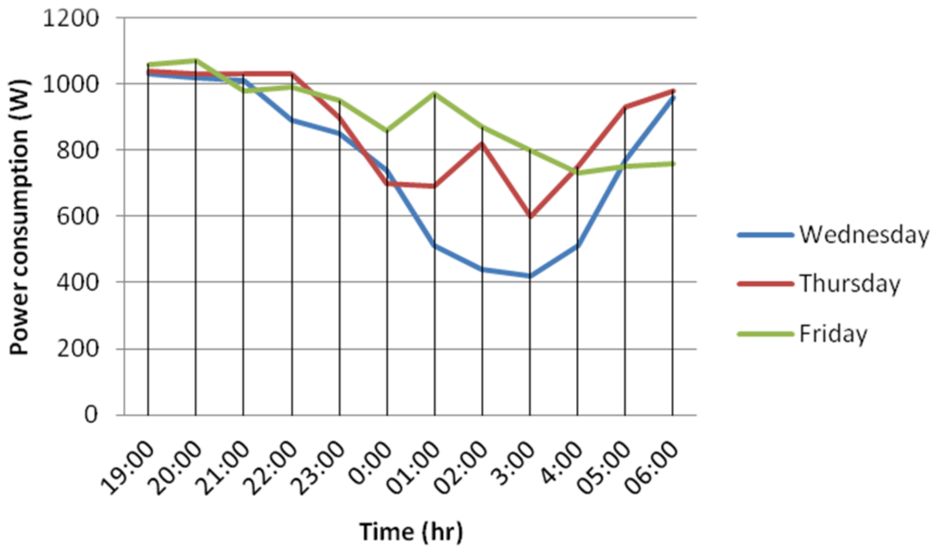
The graph (Fig 11.3) shows the total power consumption for scenario #1 for all the days in the week during the evaluation. As it is clear from the graph, the power consumption was quite high for Friday as compared to rest of the days. It is a close call between Tuesday and Wednesday while deciding about which day had the lowest power consumption.

The graph (Fig 11.4) shows the average for the whole week for scenario #1. The average highest power consumption is around 1050 Wand the lowest was around 550W.On the whole it can be deduced from the average graph that the peak hours last between 19.00- 22.00. The power consumption gradually reduces till 01.00 and stays constant from 01.00- 02.00.It reaches the minimum at 03.00 indicating hardly any movement at the site and there on it picks up and reaches a little below the level of that during peak hours.

Inferences:

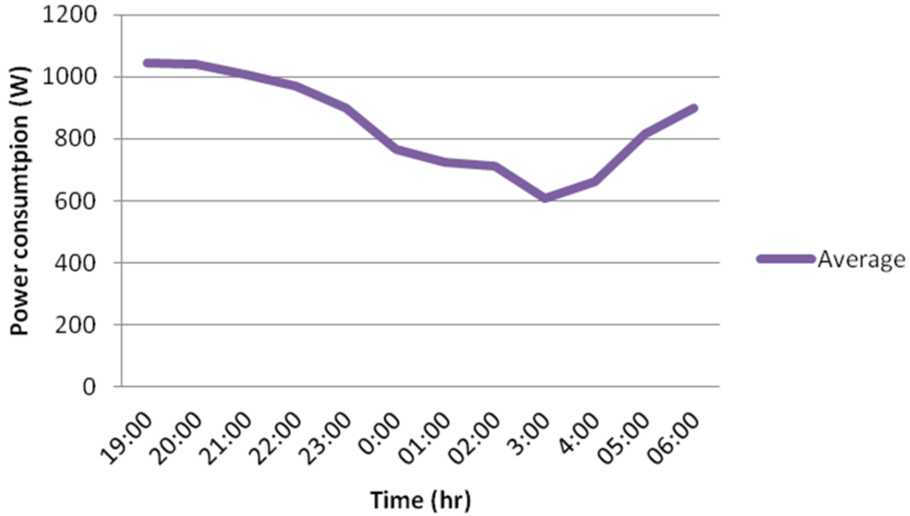
- Friday was the busiest day of the week with high power consumption levels.
- The peak hours of the traffic on an average appear to be during 19.00 -22.00 hrs. After that, the power consumption gradually decreases till 01.00hrs. It remains more or less at the same between 01.00- 02.00, especially on weekends and falls down again after 02.00 at night.
- The smooth and gradual graph line for Wednesday suggest it to be the least busy day in the week, without any sudden rises and falls in the graph.
- 03.00 is the least busy time in the night with hardly any movement in the place.
- At early 06.00 in the morning the road is just a little less busy, with a marginal difference in power consumption levels, as it is during peak hours in the evening.

From all the data, Wednesday, Thursday and Friday were the common days among all the scenarios. Hence, for a fair comparison between the energy consumption for all the scenarios, it would be relevant to compare the graphs for the common days.



(Fig 11.5) Line graph showing total power consumption for common days of scenario #1

The graph (Fig 11.5) shows the power consumption for Wednesday, Thursday and Friday for scenario#1 in the week during the evaluation. As discussed earlier, on Friday the power consumption is quite high whereas Wednesday has the lowest consumption. The consumption rises gradually towards the end of the week.



(Fig 11.6) Line graph showing total average power consumption for common days for scenario #1

The graph (Fig 11.6) shows the average for Wednesday, Thursday and Friday for scenario #1.

SCENARIO #2

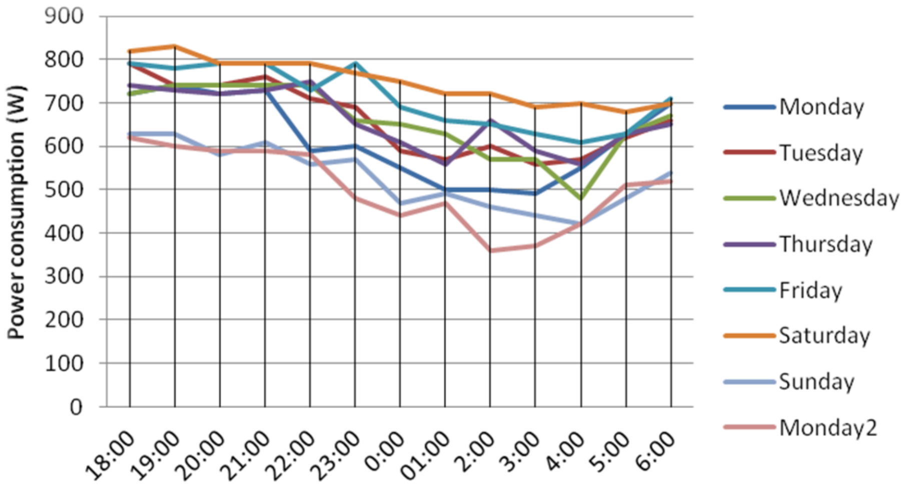
Duration: 15-10-2012 (Sunday) to 23-10-2012 (Saturday)

The conditions for the scenario are as follows:

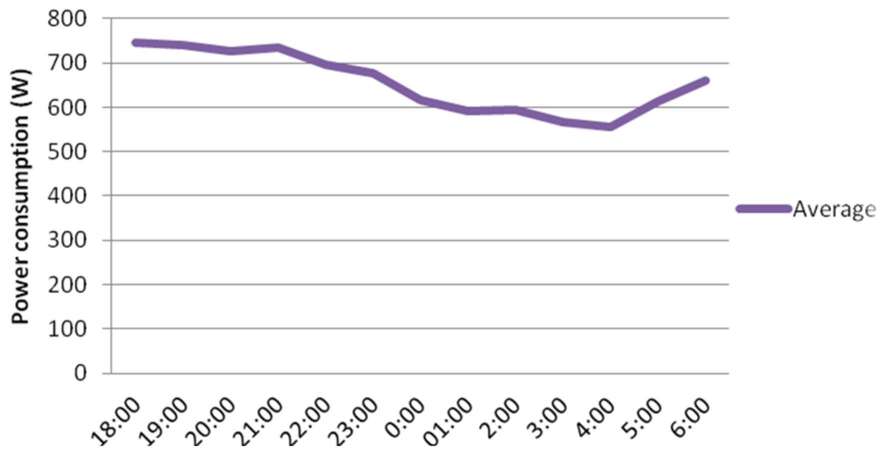
- High power 8
- Low power 5 on “mid” poles
- Low power 7 on each 3 poles at the ends
- High power for 120 seconds after activation
- High power on all poles after activation

Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*-NO-*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

(Fig 11.7) Table showing conditions for scenario #2



(Fig 11.8) Line graph showing total power consumption for scenario #2



(Fig 11.9) Line graph showing total average power consumption for scenario #2

The graph (Fig 11.8) shows the total power consumption for scenario #2 for all the days in the week during the evaluation. As seen from the graph, the power consumption was the highest for Saturday as compared to rest of the days though the value was not as high as in the case of scenario #1. There were two Mondays in this scenario, the second Monday being the least busy day during this scenario. If we consider the week from Sunday to Saturday, (excluding second Monday) we observe that the power consumption levels increase towards the end of the week; Sunday being the least and Saturday being the highest.

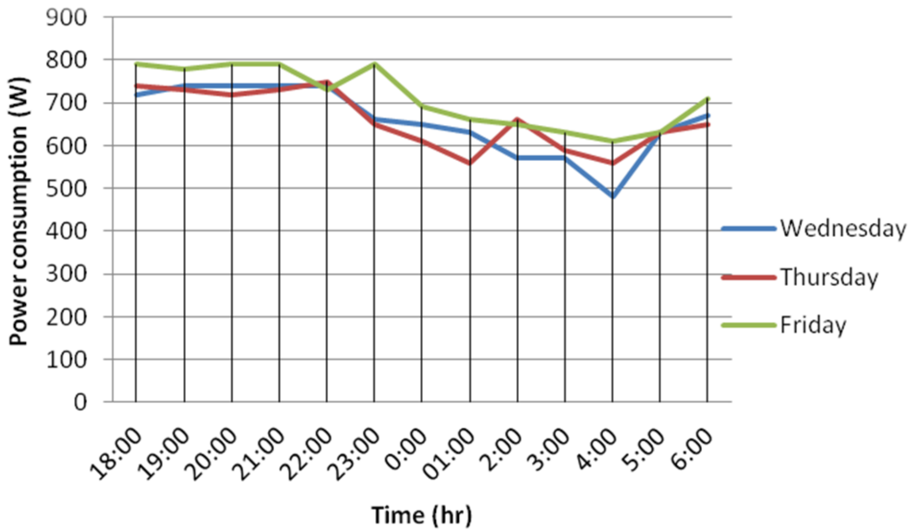
The graph (Fig 11.9) shows the average for the whole week for scenario #2. Compared to the previous scenario #1, there was a considerable reduction in the power consumption in this scenario with the maximum level being changed to level-8 from level-10. The maximum consumption didn’t exceed more than 750 W which is much lesser than the previous week although the lowest level was the same around 550W. On the whole it can be studied from the average graph that the peak hours last between 18:00- 22:30. The power consumption gradually reduces till 01:00 and stays constant from 01:00- 02:00.It drops gradually from 02:00 and reaches the minimum at 04:00, suggesting hardly any movement at the site and there on it picks up till 06:00.

Inferences:

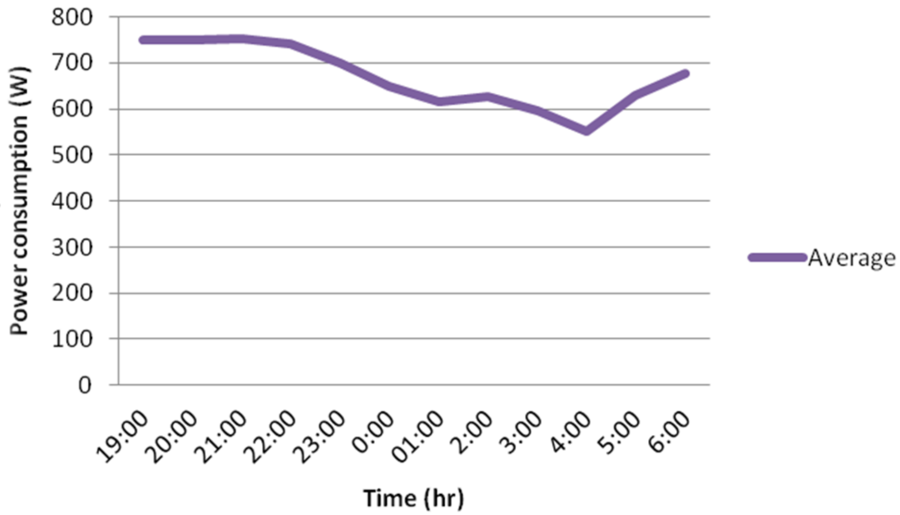
- Saturday was the busiest day of the week with high power consumption levels.
- The peak hours of the traffic on an average appear to be during 18.00 -22.30 hrs, similar to the earlier case. After that, the power consumption gradually decreases till 01.00hrs.The traffic is good between 01:00-02:00, especially on weekends and gradually falls down again after 03.00 at night. .
- From 03.00-04:00, the number of people moving is scarce, and after 04:00, it slowly the consumption levels increase slowly.

- A good amount of energy is saved from the earlier scenario by bringing down the maximum output level to ‘level-8’; the maximum average consumption didn’t exceed 750W, as compared to average value of approximately 1050 W in scenario #1.

The comparison graph for scenario#2 for the common days (Wednesday, Thursday and Friday)



(Fig 12.0) Line graph showing total power consumption for common days of scenario #2



(Fig 12.1) Line graph showing total average power consumption for common days for scenario #2

The graph (Fig 12.0) shows the power consumption for Wednesday, Thursday and Friday for scenario#2 in the week during the evaluation. As discussed earlier, on Friday, the power consumption is higher among these three days; the peak hours being from 18:00-21:00 hrs and at 23:00 at night. The consumption on Wednesday is the lowest, while Thursday has a medium level of consumption among these three days. The power consumption is seen rising gradually towards the end of the week.

The graph (Fig 12.1) shows the average for Wednesday, Thursday and Friday for scenario #2.

SCENARIO #3

Duration: 24-10-2012 (Wednesday) to 28-10-2012 (Sunday)

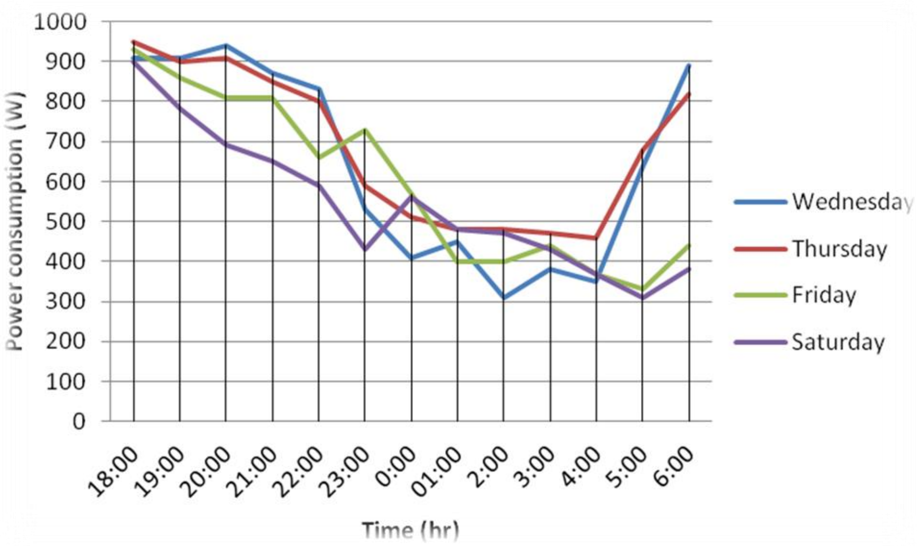
The conditions for the scenario are as follows:

- High power 10 (full)
- Low power 5 on “mid” poles
- Low power 7 on each 3 poles at the ends
- High power for 120 seconds after activation
- High power on 7 poles (3 poles before+ pole at current position + 3 poles after) after activation

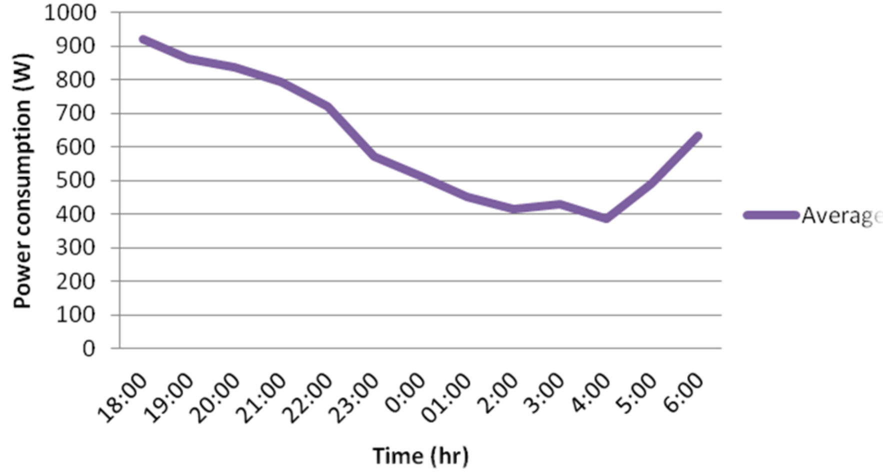
Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*-NO-*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

(Fig 12.2) Table showing conditions for scenario #3

NOTE: This scenario had the shortest duration i.e. from Wednesday to Saturday, for the installation due to technical problems.



(Fig 12.3) Line graph showing total power consumption for scenario #3



(Fig 12.4) Line graph showing total average power consumption for scenario #3

The total power consumption for scenario #3 is shown in the graph (Fig 12.3) for all the days (from Wednesday- Saturday) in the week during the evaluation. Analysing the graph, it is difficult to say which day had the highest power consumption and which one had the lowest, as it is quite distributed unlike the earlier cases. One reason behind this could be that the data was recorded only during a span of 4 days. By calculating the average, Thursday has the highest power consumption while Saturday has the lowest. It is interesting to note that Thursday didn't have much variation in the values from 01:00 to 04:00. Friday had sharper peaks and dips till 01:00 as seen in the graph. The highest value reached was 950 W during 18:00 and 20:00 on Thursday and Wednesday respectively. In this scenario the lowest level of consumption touched as low as 300 W, which is the lowest value as compared to previous scenarios #1 and #2.

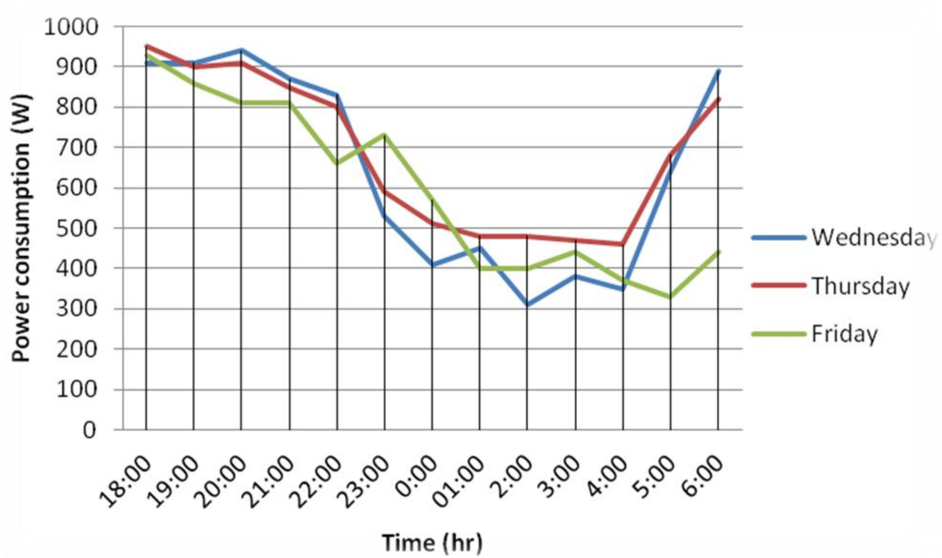
The graph (Fig 12.4) shows the average for the whole week for scenario #3.There is a big dip in the average lowest power consumption (around 380W) which is favourable, but since the scenario lasted just for 4 days, the values cannot be completely reliable. The highest value was around 940 W, which is higher than in the case of scenario#2 (maximum light level – 8) but lower than of scenario #1 (maximum light level – 10). On the whole it is apparent from the average graph that the peak hours last between 18:00- 22:00, similar to previous cases. The power consumption gradually reduces till 01:00 and doesn't vary much from 01:00- 04:00, reaching the lowest value at 04:00. A rise in the value is again seen from 04:00, like in the case of scenario #2.

Inferences:

- It is difficult to find out the busiest day in this week as it is not obvious from the graph. But considering the average values for each day, Thursday proves to be the busiest of all the rest of the days. However during the peak hours (18:00-22:00), Wednesday and Thursday seem to be the busiest days.

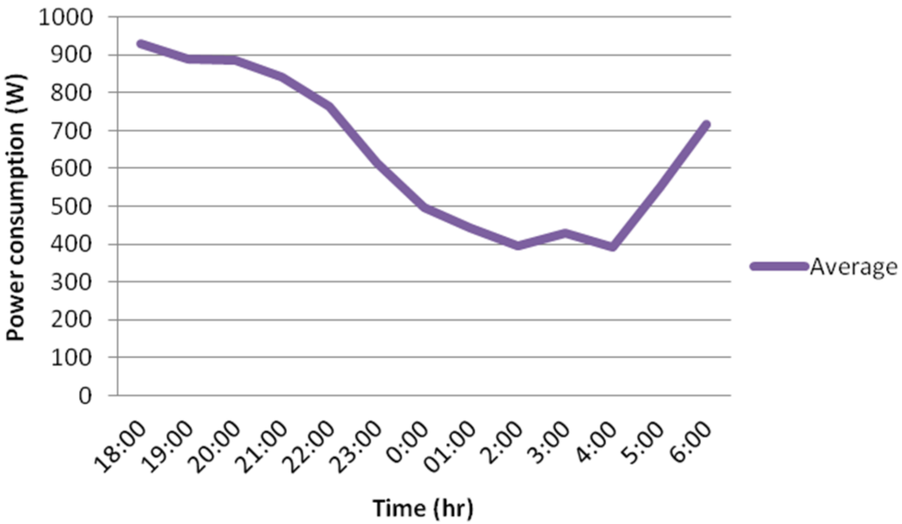
- The peak hours of the traffic on an average appear to be during 18.00 -22.00 hrs, similar to the earlier cases. After that, the power consumption gradually decreases till 01.00hrs and picks up again after 04:00.
- From 01.00-04:00, the number of people moving is scarce but more or less same for all the days except for Wednesday. Hence the power levels from 01:00-04:00 vary within a small margin of 50-60W as seen from the average graph. (Fig 10.2)
- The highest average value for the power consumption is higher than the scenario #2 which had the maximum light level at 8 , hence making it less energy-efficient (probably due to higher light level of 10) as compared to the previous case.

The comparison graph for scenario#3 for the common days (Wednesday, Thursday and Friday)



(Fig 12.5) Line graph showing total power consumption for common days of scenario #3

The graph (Fig 12.5) shows the power consumption for Wednesday, Thursday and Friday for scenario#3 in the week during the evaluation. As discussed earlier, Thursday has the highest power consumption values among all days; the peak hours being from 18:00-21:00 hrs with the value at its peak at 18:00hrs, although the highest value of 950W among the three days is on Wednesday at 20:00hrs.The consumption on Friday is the lowest, while Wednesday has a medium level of consumption among these three days.



(Fig 12.6) Line graph showing total average power consumption for common days for scenario #3

The graph (Fig 12.6) shows the average for Wednesday, Thursday and Friday for scenario #3.

SCENARIO #4

Duration: 30-10-2012 (Tuesday) to 04-11-2012 (Sunday)

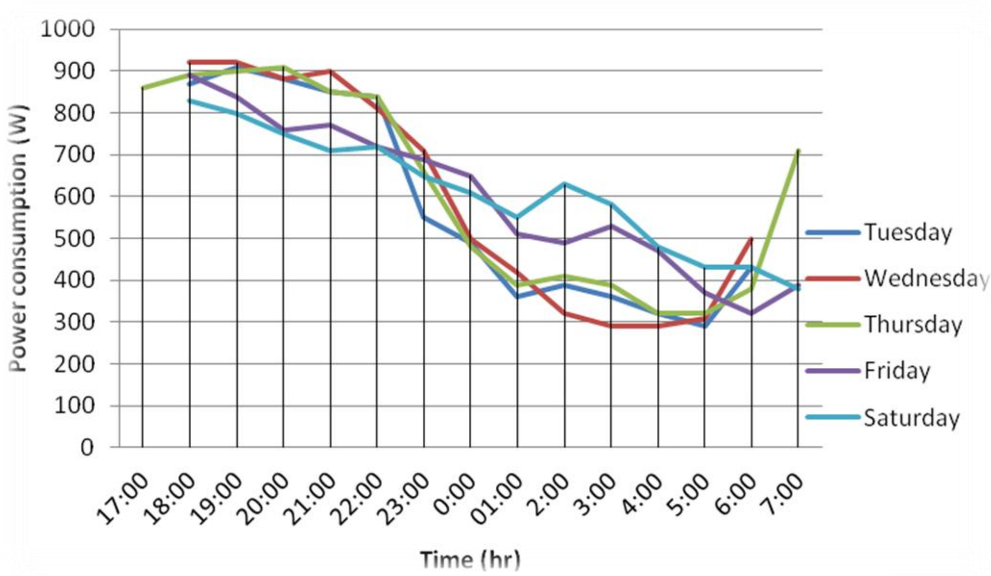
The conditions for the scenario are as follows:

- High power 10 (full)
- Low power 5 on “mid” poles
- Low power 7 on each 3 poles at the ends
- High power for 60 seconds after activation
- High power on 7 poles (3 poles before+ pole at current position + 3 poles after) after activation

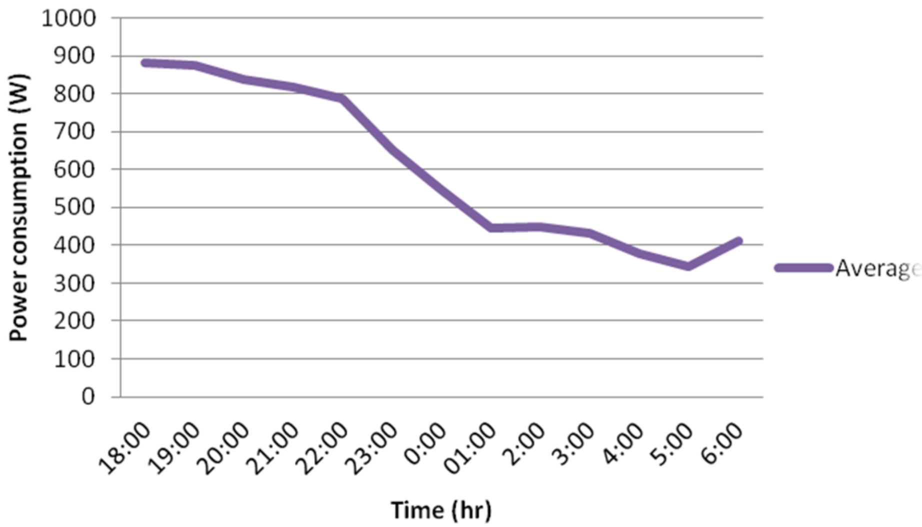
Scenario	*Low Power level*	*High Power level*	*Number of poles*	*Timer setting (s)*
# 0	*10*	*10*	*All*	*-NO-*
# 1	*5 (7 for first 3)*	*10*	*All*	*120*
# 2	*5 (7 for first 3)*	*8*	*All*	*120*
# 3	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*120*
# 4	*5 (7 for first 3)*	*10*	*7 (3+1+3)*	*60*

(Fig 12.7) Table showing conditions for scenario #4

NOTE: This scenario had the same conditions as the previous scenario#3 except for the fact that the timer settings was reduced from 120 seconds to 60 seconds to test scenarios with different time settings to notice any considerable change in terms of energy consumption.



(Fig 12.8) Line graph showing total power consumption for scenario #4



(Fig 12.9) Line graph showing total average power consumption for scenario #4

The total power consumption for scenario #4 is shown in the graph (Fig 12.8) for all the days (from Tuesday- Saturday) in the week during the evaluation. Looking at the graph, Saturday has the highest power consumption level and Wednesday has the lowest. It is interesting to note a steep rise in the graph for Saturday between 01:00-02:00 and gradually drops down after 02:00 late in the night unlike the rest of the days in the week. The graph picks up again after 05:00 in the morning, and on Thursday there is a sudden rise in the value after 06:00. The highest value reached was around 920 W during 18:00-19:00 on Wednesday. In this scenario the lowest level of consumption touched as low as 300W to 290W, which is the approximately the same as in scenario #3.

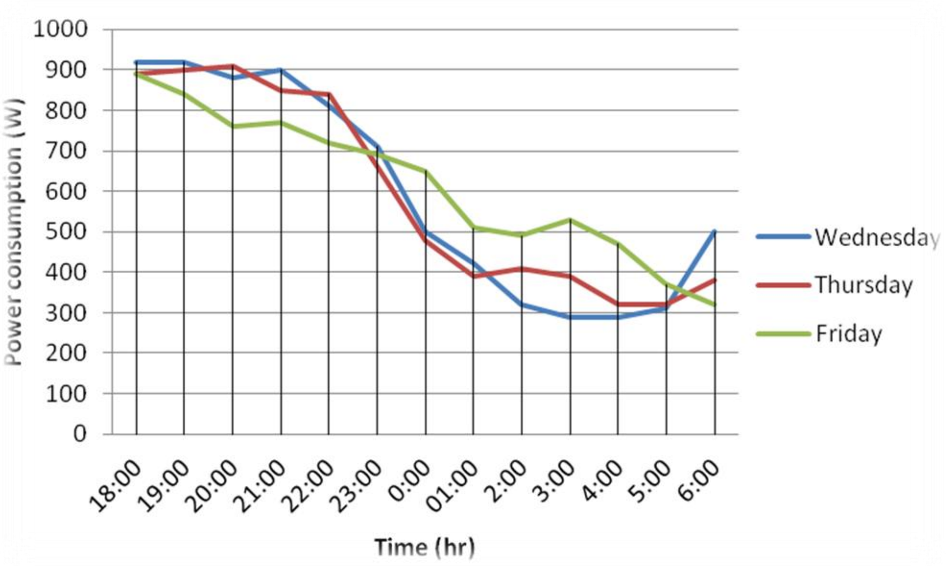
The graph (Fig 12.9) shows the average for the whole week for scenario #4. The average lowest power consumption level fell down to 350W, which is better than rest of the scenarios. On the whole it is clear from the average graph that the peak hours last between 18:00- 22:00, matching the earlier cases. The power consumption drastically falls from 22:00 till 01:00 and doesn't vary much from 01:00- 03:00, reaching the lowest value at 05:00. A rise in the value is again seen from 05:00 to 06:00.

Inferences:

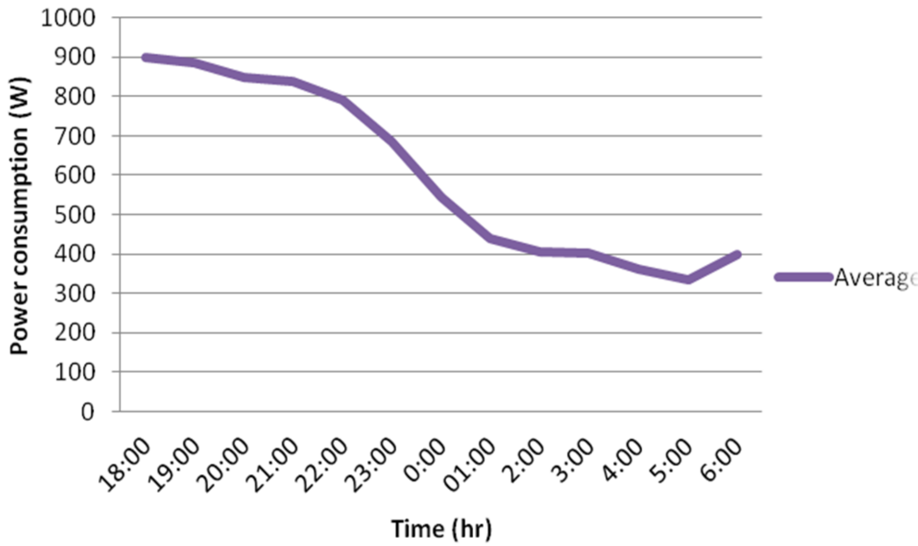
- Saturday proves to be the busiest of all the rest of the days; however it never reached the peak values during the busy hours (18:00-22:00). Wednesday and Thursday achieved the peak power consumption values during the busy hours.

- Considering the average graph, the road is the busiest from 19.00 -22.00 hrs, similar to the earlier cases. The line-graph showing the power consumption drastically falls afterwards till 01.00hrs maintains more or less the same values until 03:00 and picks up again after 05:00.
- From 01:00-03:00, the number of people moving is scarce but quite the same for all the days except for Saturday where there is a rise between 01:00-02:00 and again trips down after 02:00.
- The highest average value for the power consumption is higher than the scenario #2 but lesser than #3, hence making it moderately energy-efficient as compared to the previous cases.

The comparison graph for scenario#3 for the common days (Wednesday, Thursday and Friday)



(Fig 13.0) Line graph showing total power consumption for common days of scenario #4



(Fig 13.1) Line graph showing total average power consumption for common days for scenario #4

The graph (Fig 13.0) shows the power consumption for Wednesday, Thursday and Friday for scenario#4 in the week during the evaluation. Thursday has the highest power consumption values among these 3 days; the peak hours being from 18:00-21:00 hrs with the value at its peak at 18:00hrs, although the highest value of 920W among the three days is on Wednesday between 18:00-19:00.The consumption on Wednesday is the lowest, while Friday has a medium level of consumption among these three days although the difference in the values among the average power consumption values of all of them is hardly 5 W.

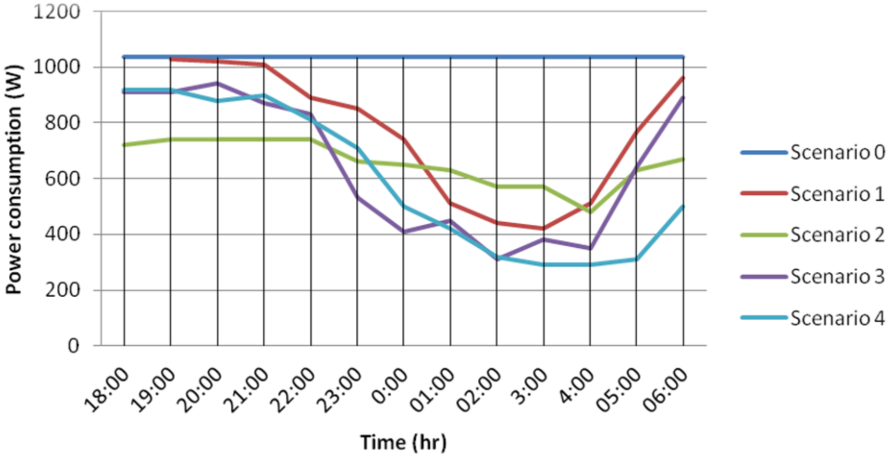
The graph (Fig 13.1) shows the average for Wednesday, Thursday and Friday for scenario #4.

COMPARATIVE ANALYSIS FOR COMMON DAYS AMONG ALL THE SCENARIOS

As discussed earlier, evidently from all the data, Wednesday, Thursday and Friday were the common days among all the scenarios. Hence, for a fair comparison between the energy consumption for all the scenarios, it would be relevant to compare the power consumption graphs for the common days.

(Fig 13.2) – Graph depicting the power consumption values for all Wednesdays for scenarios #1 to scenario #4

From the graph it is seen that the times at which the graph falls down is almost the same, i.e. after 22:00 in the night, however the values vary considerably. It again picks up after 04:00 and starts going up till 06:00 when the installation ultimately is turned off. Analysing the graph it is found out that there is a decreasing trend in the power consumption levels from scenario #1 to scenario #4, i.e. scenario #1 being the least energy-efficient scenario and scenario #4 being the most energy-efficient one for all the Wednesdays.



(Fig 13.2) Graph comparing the power consumption levels for all Wednesdays.

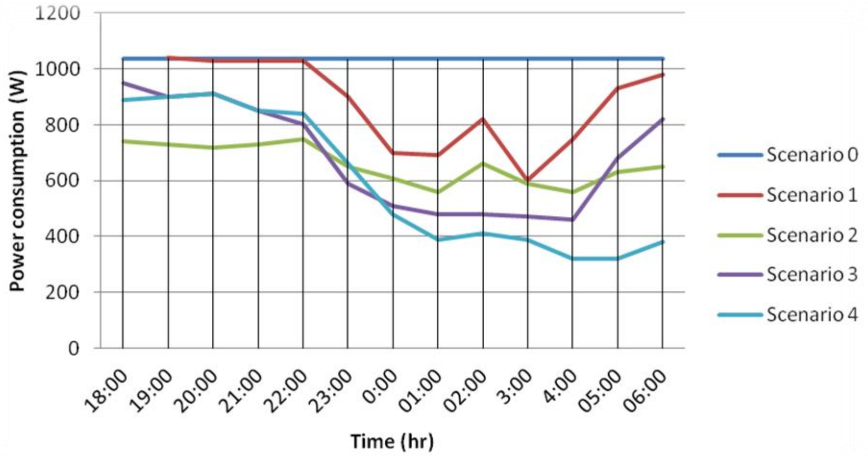
Power consumption values for Wednesdays in decreasing order can be represented as:

Scenario#1 > Scenario #2 > Scenario #3 > Scenario #4

Highest power consumption values to lowest power consumption values.

(Fig 13.3) – Graph depicting the power consumption values for all Thursdays for scenarios #1 to scenario #4

From the graph it is derived that the times at which the graph falls down is almost the same, i.e. after 22:00 in the night, however the values in this case, also vary considerably. It is clear from the graph that in case of scenario #1, the power consumption levels are way higher than the rest of the scenarios and has sharp peaks and dips, whereas in the rest of the cases it is not too fluctuating. After the low consumption levels from 22:00 till 03:00-04:00 in the night, it again picks up after 04:00 and starts going up till 06:00 when the installation ultimately is switched off. Analysing the graph, it is deduced that scenario #1 is the least



(Fig 13.3)Graph comparing the power consumption levels for all Thursdays.

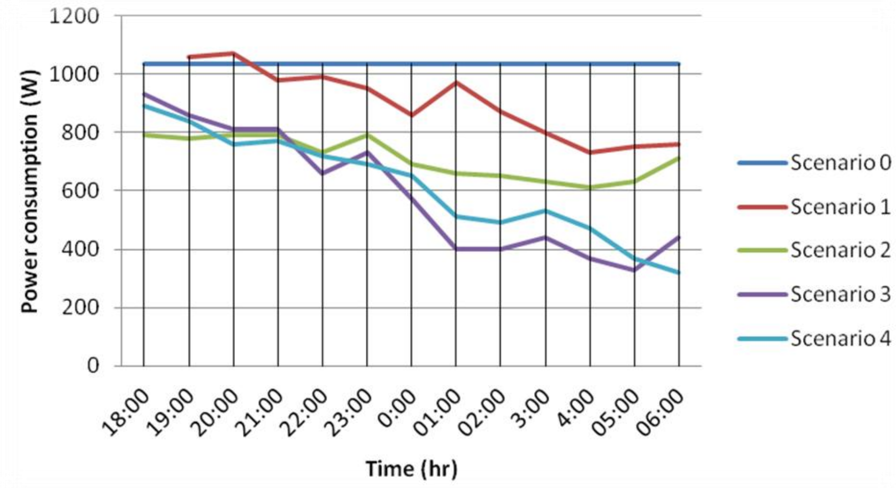
energy- efficient scenario while scenario #4 being the most energy-efficient one for all the Thursdays.

Power consumption values for Thursdays in decreasing order can be represented as:

Scenario#1 > Scenario #3 > Scenario #2 > Scenario #4

Highest power consumption values to lowest power consumption values.

(Fig 13.4) – Graph depicting the power consumption values for all Fridays for scenarios #1 to scenario #4



(Fig 13.4) Graph comparing the power consumption levels for all Fridays.

From the graph it can be studied that the times at which the graph falls down is almost the same, i.e. after 22:00 in the night, however the values in this case, also vary considerably. It is clear from the graph that in case of scenario #1, the power consumption levels are way higher than the rest of the scenarios and has sharp peaks and dips, whereas in case of scenario # 3 and #4 also, the values drop down considerably after 23:00 from a peak. The graph for scenario #2 is comparatively much gradual and smoother than the rest. In all the scenarios, there is a change from 00:00 to 01:00 – in scenario #1; it reaches up whereas in rest of the cases, it is the opposite. After the low consumption levels from 22:00 till 03:00-04:00 in the night, it again picks up after 05:00 (an hour later than the previous case) except in case of scenario #4 (where it never picks up) and starts going up till 06:00, when the installation ultimately is switched off. Analysing the graph, it is deduced that scenario #1 is the least energy- efficient scenario while scenario #3 being the most energy-efficient one for all the Fridays.

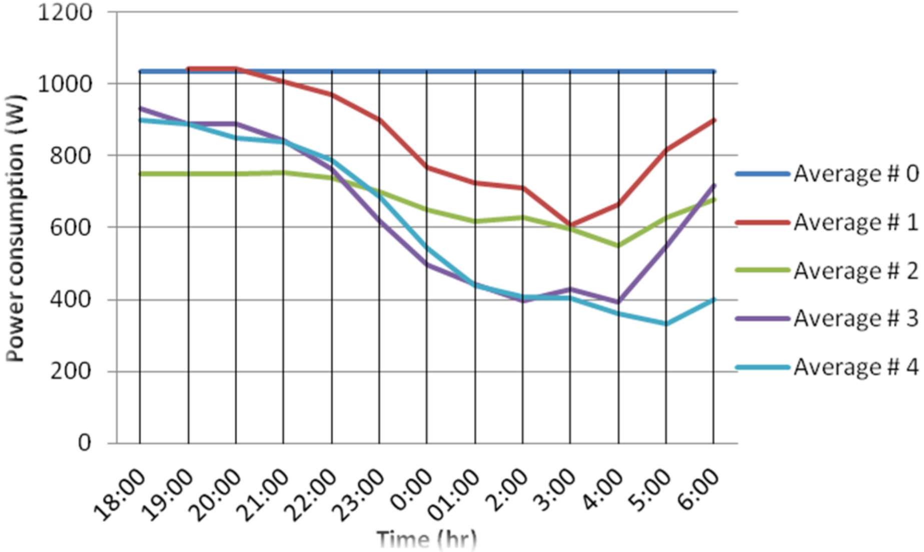
Power consumption values for Thursdays in decreasing order can be represented as:

Scenario#1 > Scenario #2 > Scenario #4 > Scenario #3

Highest power consumption values to lowest power consumption values.

COMPARATIVE ANALYSIS FOR AVERAGE POWER CONSUMPTION VALUES FOR COMMON DAYS (WED-FRI) AMONG ALL THE SCENARIOS

The adjacent graph (Fig 13.5) compares all the average power consumption values during the common days (Wednesday to Friday) for all the scenarios. This graph can be considered as the most relevant one in order to compare the power consumption levels of the same days of different weeks comprising of different scenarios within a certain time-frame.



(Fig 13.5) Graph comparing the average power consumption levels for all the scenarios

From the graph it is apparent that the times at which the graph falls down is again the same, i.e. after 22:00 in the night, however the values vary considerably. It drops down further gradually after 00:00-01:00 in the night indicating low frequency of people along the stretch. However in the case of scenario #2, the values don't fluctuate as much as in the rest of the scenarios, forming a smooth gradient/slope in the graph unlike others.

In scenario#1, the values progress upwards suddenly after 03:00; in scenarios #2 and #3, this growth is seen only after 04:00, where as in scenario #4, it takes off after 05:00. Hence it can be concluded that during 00:00 till 03:00, there is least movement along the installation site.

Coming to the busy hours, 18:00 to 22:00 is the busiest period in all the cases, and as the line graphs indicate, the people again start moving along the path by 04:00 in the early morning and the frequency goes up till 06:00 when the lights are turned off for the day with the daylight.

Result - The graph depicts the most energy-efficient scenario and the least energy-efficient scenario. Thus, the scenarios can be arranged in the following order in terms of energy consumption:

SCENARIO #0 > SCENARIO #1 > SCENARIO #2 > SCENARIO #3 > SCENARIO #4

1035 W > 845.55 W > 676.15 W > 642.82 W > 603. 07 W

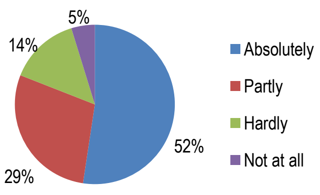
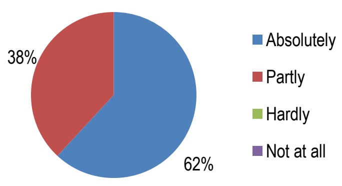
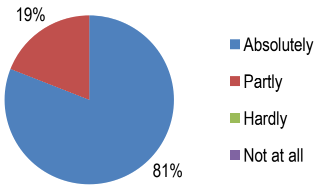
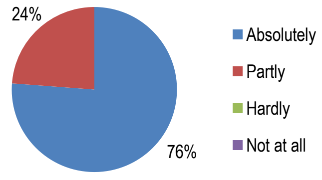
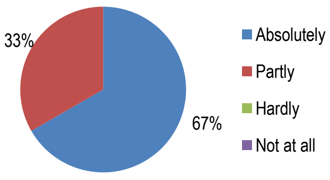
Highest power consumption values to lowest power consumption values.

Observations - Scenario #3 and #4 have lesser number of poles with maximum output unlike the other scenarios in which the whole stretch goes up to the maximum light level with the control systems. Also, scenario #4 has shortest timer settings among all the others. This could be one of the important factors which make the last two scenarios energy- efficient compared to the rest though scenario #2 had maximum light level of 8.

COMPARATIVE ANALYSIS

6.1 COMPARISONS REGARDING THE SAFETY, VISUAL COMFORTABILITY AND PERCEPTION AMONG SCENARIOS

6.1 (a) The table below shows the results from scenario #0 to scenario #4 in terms of **SAFETY:**

				
SCENARIO #0	SCENARIO #1	SCENARIO #2	SCENARIO #3	SCENARIO #4

(Fig 13.6) Table showing the results of safety among people

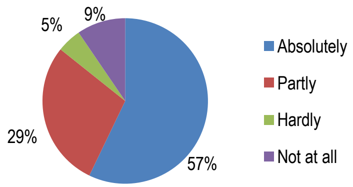
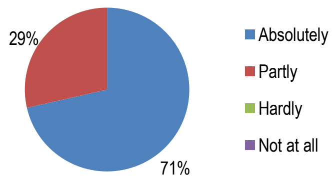
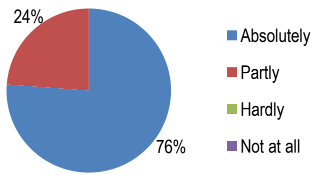
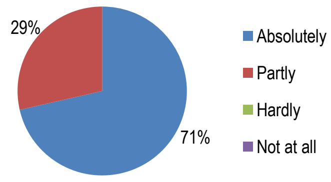
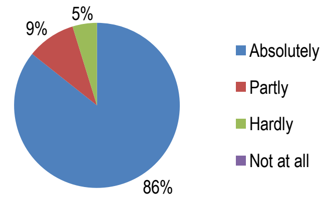
During the interactions with the users on the site, the answers obtained were distributed among just two options of 'absolutely safe' and 'partly safe', except in case of scenario #0. Coming to the ranking of the scenarios regarding the aspect of safety, the percentage of people who felt 'absolutely safe' in the space was taken as the determining factor to list down the order of preference. Analysing the table (Fig 13.6), the following result was derived:

- Concerning the safety, the scenarios can be arranged starting from the safest to the least safe scenario as follows:

SCENARIO#2 > SCENARIO #3 > SCENARIO #4 > SCENARIO #1 > SCENARIO #0

Decreasing level of safeness

6.1 (b) The table below shows the results from scenario #0 to scenario #4 in terms of **VISUAL COMFORTABILITY:**

				
SCENARIO #0	**SCENARIO #1**	**SCENARIO #2**	**SCENARIO #3**	**SCENARIO #4**

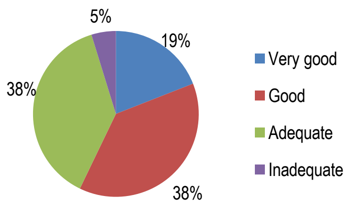
(Fig 13.7) Table showing the results of visual comfortability among people

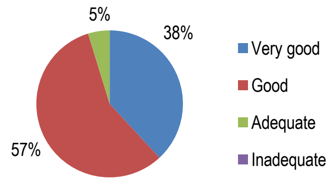
The results regarding the judgement of scenarios in order of preference would be based on the answers of question no. 6 from the questionnaire. On comparing the above graphs based on the percentage of people who felt the light was 'absolutely good' in the space, the scenarios can be arranged starting from the most comfortable to the least comfortable scenario as follows:

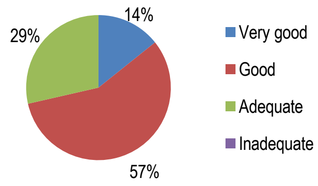
SCENARIO#4 > SCENARIO #2 > SCENARIO #3 = SCENARIO #1 > SCENARIO #0

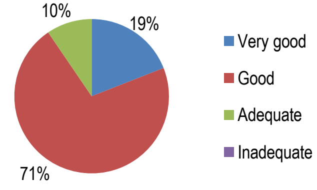
Decreasing level of visual comfortability

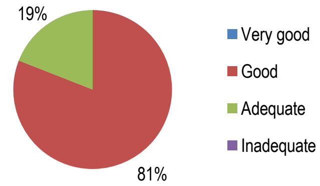
6.1 (c) The table below shows the results from scenario #0 to scenario #4 in terms of **PERCEPTION:**











(Very good +Good)% = 57%	(Very good +Good)% =95%	(Very good +Good)% =71%	(Very good +Good)% =90%	(Very good +Good)% =81%
SCENARIO #0	SCENARIO #1	SCENARIO #2	SCENARIO #3	SCENARIO #4

(Fig 13.8) Table showing the results of perception among people

In the case of 'perception' aspect for the lighting scenarios, the sum total percentages of 'very good' and 'good' were taken into account as the basis for ranking them in order of preference. The results regarding the judgement of scenarios in order of preference would be based on the answers of question no. 7 from the questionnaire. On comparing the above graphs based on the sum total of percentage of people who perceived the space "good" and "very good", the scenarios can be arranged starting from the most to the least preferred scenario as follows:

SCENARIO#1> SCENARIO #3 > SCENARIO #4 > SCENARIO #2 > SCENARIO #0

Decreasing level of good perception

6.2 RANKING* AMONG ALL SCENARIOS (summing up all the aspects)

The table below shows the results from scenario #0 to scenario #4 and rated on a scale of 1 to 5, in order to choose the best scenario among all five of them.

SCENARIO	USER RESPONSES			ENERGY VALUES	RESULT
	SAFETY	*VISUAL COMFORT*♦	*PERCEPTION*	ENERGY CONSUMPTION *(Based on the average values for the common days)*	
#0	1	1	1	1	**4**
#1	2	2	5	2	**11**
#2	5	3	2	3	**13**
#3	4	2	4	4	**14**
#4	3	4	3	5	**15**

(Fig 13.9) Table showing the final rankings in order of preference among scenarios

** In the table (Fig.13.9), the scenarios have been numbered by the order of preference, i.e. 5 indicating the most preferred and 1 indicating the least preferred situation. Hence the scenario which has the maximum total value in the result section is the most preferred scenario and the one with the least sum value is the least preferred scenario.*

NOTE: In the column of '*VISUAL COMFORT*♦', both scenario #1 and #3 have been ranked the same as they gave the same results in the evaluation in section 6.1(b). Hence the scale also ranges from 1 to 4, instead of 1 to 5 as in case of other columns of 'safety' and 'perception'.

RESULTS

- Studying all the data and the comparative analysis table in the previous section, scenario #4 proves to be the most favourable among them followed closely by scenario #3.
- Scenario #0, which is a stable lighting situation without any active lighting control system, is the least preferable scenario.
- If the scenarios are to be arranged in order of preference based on both visual and technical evaluation, the order would be as follows :

SCENARIO #0 < SCENARIO #1 < SCENARIO #2 < SCENARIO #3 < SCENARIO #4

Increasing order of preference →

CONCLUSIONS

Thorough study and evaluation of the project led to the discovery of a lot of interesting aspects. These aspects include observations and analysis of the situation, suggestions and areas of improvement for further development in this field. These aspects are summarized according to the chronological order of the report as below:

1. PROJECT GOALS:

- *'While there is a risk that controlling the environment in itself defeats the purpose of creating a secure and transparent environment, project will examine how governance should be designed so as not to jeopardize the safety of users comfort.'*

  There were five different experimental scenarios and after analysing them it was observed that the people could never consciously notice the change in the lighting situation from a stable situation to that with the control systems. This, in a way is a positive indication that the users didn't realise that they are in a controlled environment and hence nullifies the question of jeopardising the safety of users in a controlled environment.

- *'Technology assessment (energy savings, reliability, etc.) will be related to how users perceive visual quality, safety and security.'*

  From the results of all the scenarios, it is evident that among the five scenarios, there were a few scenarios (Scenario #2 and #3) which struck a balance between energy efficiency, perception of visual quality, safety and security within the environment.

- *'For the pilot project involving lighting control, the idea is to provide a saving potential between 40-60% of energy use, compared with the old traditional system (high- pressure sodium lamps). By installing an intelligent lighting control that reduces lighting levels at night, is estimated to reduce more than 30% for the remaining energy.'*

  The average values of power consumption for each of the scenarios are as below:

SCENARIO #0 > SCENARIO #1 > SCENARIO #2 > SCENARIO #3 > SCENARIO #4
1035 W > 845.55 W > 676.15 W > 642.82 W > 603.07 W

From the power consumption values, the percentage of energy savings (with presence control system) considering scenario #0 (stable situation without presence control system) as the basis of comparison can be calculated for each scenario as below:

Scenario #1: $\left[1 - \frac{845.55}{1035}\right] \times 100 = 18.4\%$

Scenario #2: $\left[1 - \frac{676.15}{1035}\right] \times 100 = 34.7\%$

Scenario #3: $\left[1 - \frac{642.82}{1035}\right] \times 100 = 37.9\%$

Scenario #4: $\left[1 - \frac{603.07}{1035}\right] \times 100 = 41.8\%$

So starting from scenario #0 to scenario #4, the amount of energy saved increases from approximately 18 to 42%. The highest amount of energy saved is 42%, which is 10% more than what was stated in the project goals. Also, the preferred situation of scenario #2 and scenario #3 save 34.7% and 37.9%, which is also more than what was anticipated.

- *'The evaluation will lead to strategies (possibly multiple) for illumination of the path that meets the balanced energy-efficiency, economy and comfort of road users (security, safety, visual quality).'*

From all the evaluation and the results, scenario #2 and #3 both form good solutions for the lighting involving control systems and meet the project goals of achieving strategies for illumination of the path that meets balanced energy efficiency, economy and comfort of the users in terms of safety, security and visual quality.

2. SITE CONTEXTUAL DISCUSSION

Surroundings certainly have a vital effect on the perception of the users regarding safety and human vision in the space. The following points are of relevance in terms of the site and context which provides useful information regarding the lighting situation:

- The dark and dense foliage in the surroundings affected the human field of vision and gave the space a closed kind of impression making the people feel more vulnerable of any attack. Since the dark colour of the leaves didn't reflect much light and obstructed the view to look beyond the trees, the people felt more anxious and unsecure. This phenomenon was even prominent where the road stretch was narrow and at a closer proximity to the trees due to the lack of good, spread surrounding light compared to the road stretch where it was broader and catches more light, broadening the field of vision, thus creating an impression of safe environment.

- The colour of the leaves on the trees changed the picture of the place. The light coloured yellow leaves on the trees during late autumn reflected a good amount of light, making it appear much brighter although the light levels were much lower or the same than before. The same effect was observed on the cloudy days, where the clouds reflected light, making the sky look brighter and hence affecting the perception of brightness in the space.

- It must be kept in mind that the lighting situation on the site was not independent and isolated but was affected by the surrounding light from the other light sources, viz., the reflections from the water, the street lighting across the water body, light from the neighbouring buildings etc. This might have affected the responses from the users. This is supported by the fact that about 80% of the people didn't notice the changed lighting along the road, though most of them used the path regularly. Had the site been a lighting situation in an isolated place without any interference of external light, the people might have noticed it. Hence, the location of the site (isolated or in a bigger lit environment) affects the perception of the lighting in a sub-conscious way.

- Lighting of the vertical surfaces is equally important as the lighting on the horizontal surface of the road.

- ***Suggestions*** – Majority of the people using the space felt that the space can be improved in terms of ambience, may be by adding some decorative light or with some different lighting effects, thus making it more livelier along the water side and encouraging people to use the space for socialising, relaxing and recreation rather than using it just as a walkway or a jogging path.

3. SAFETY:

- Men, generally felt safer than women in the environment. However, majority of both men and women who felt unsafe in the space admitted that their perception of safety is irrespective of the lighting but more associated with the presence or absence of people. According to them, isolated places without people feel more unsafe. Area/locality and time of the day also make a difference in the perception of safety.

- Cultural background of the people also is an interesting factor which changes the perception of safety noticeably.

- The youngest age group (under 20 years) are the most vulnerable lot when it comes to safety, whereas majority of the oldest generation (above 60 years) feel secure in the environment.

- Few of the people associate safety with light levels. Brighter spaces make people feel safer, but this might be subjected to psychological conditioning of the mind.

- The people comprising of 20-40 and 40-60 age group have mixed responses regarding the feeling of safety in the space, although majority of them expressed to feel completely safe in the space.

4. VISUAL COMFORTABILITY:

- General conception of the people regarding the quality of light is positive. They find it good and comfortable.

- The satisfaction levels of older age groups (above 60 years and 40-60 years) are much higher than that of the youngest and middle aged groups (under 20 and 20-40 years).

5. GENERAL FEELING AND PERCEPTION OF THE SPACE:

- On the whole, based on the evaluation, people were positive about the atmosphere and the lighting situation. The only suggestion, as discussed above, was to improve the aesthetics of the space along the water side with some decorative light or lighting effects along with functional public lighting.

6. OVERALL:

- The idea of energy efficiency is positively embraced by the people without compromising on their comfort levels.

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LIST OF ILLUSTRATIONS

1. Cover page black and white photograph – www.flickr.com/photos/le-fauve/4092876607

2. All the photographs and processed images in the section of [5.1.c. Luminance data] were produced by Effrosyni Stragali in October –November 2012.

3. All the images in the section of [4 .Technical information for the installation] were taken from ‘Installationsanvisning Kungsholmsstrand ver I’ report.

4. All the rest of the figures are produced by the author.

APPENDIX

- **APPENDIX 1 _LUX MEASUREMENT TABLES**

- **MEASUREMENT TABLES FOR LUX READINGS – LEVEL 8**

Power Level 8		
x (m)	y (m)	lux readings
0	0.77	2.9
2	0.77	5.5
4	0.77	6.3
6	0.77	6.3
0	2.32	2.3
2	2.32	4.2
4	2.32	6.7
6	2.32	6.7
0	3.87	2
2	3.87	2.9
4	3.87	4.5
6	3.87	4.5
0	5.42	1.4
2	5.42	2.3
4	5.42	2.9
6	5.42	2.4
0	6.97	1.3
2	6.97	1.6
4	6.97	2.1
6	6.97	1.6
0	8.52	1.4
2	8.52	1.8
4	8.52	2.3
6	8.52	2.2
0	10.07	1.5
2	10.07	2.3
4	10.07	3.2
6	10.07	3.5
0	11.62	1.8
2	11.62	3.3
4	11.62	5.4
6	11.62	6.3
0	13.17	2.5
2	13.17	4.6
4	13.17	6.9
6	13.17	6.9
0	14.72	2.8
2	14.72	5.6
4	14.72	6.5
6	14.72	6.5

0	16.365	2.8
2	16.365	5.8
4	16.365	6.5
6	16.365	6.6
0	18.115	2.3
2	18.115	4.1
4	18.115	6.5
6	18.115	7.3
0	19.865	1.7
2	19.865	2.6
4	19.865	4
6	19.865	4.5
0	21.615	1.2
2	21.615	1.6
4	21.615	2.1
6	21.615	0.8
0	23.365	1
2	23.365	1.3
4	23.365	2.5
6	23.365	1.2
0	25.115	1.1
2	25.115	1.3
4	25.115	1.6
6	25.115	1.6
0	26.865	2.2
2	26.865	2.5
4	26.865	2.1
6	26.865	2.3
0	28.615	1.5
2	28.615	2.4
4	28.615	3.7
6	28.615	4
0	30.365	2.3
2	30.365	3.6
4	30.365	5.7
6	30.365	6.6
0	32.115	2.6
2	32.115	4.9
4	32.115	6.2
6	32.115	6.3

- **MEASUREMENT TABLES FOR LUX READINGS – LEVEL 10**

Power Level 10		
x (m)	y (m)	lux readings
0	0.77	3.1
2	0.77	7.1
4	0.77	8.2
6	0.77	8.3
0	2.32	2.7
2	2.32	5.5
4	2.32	8.7
6	2.32	8.9
0	3.87	2.2
2	3.87	3.5
4	3.87	5.8
6	3.87	6.3
0	5.42	1.2
2	5.42	2.3
4	5.42	3
6	5.42	3.1
0	6.97	1.3
2	6.97	1.8
4	6.97	2.3
6	6.97	2.5
0	8.52	1.5
2	8.52	1.9
4	8.52	2.5
6	8.52	2.6
0	10.07	1.5
2	10.07	2.4
4	10.07	3.6
6	10.07	3.7
0	11.62	2.1
2	11.62	3.7
4	11.62	6.2
6	11.62	6.8
0	13.17	2.8
2	13.17	5.5
4	13.17	8.8
6	13.17	8.7
0	14.72	3.2
2	14.72	7
4	14.72	8.1
6	14.72	8.5

0	16.365	3.2
2	16.365	7.5
4	16.365	8.6
6	16.365	8.6
0	18.115	2.5
2	18.115	4.9
4	18.115	8.8
6	18.115	8.8
0	19.865	1.7
2	19.865	2.8
4	19.865	5.3
6	19.865	6
0	21.615	1.2
2	21.615	1.8
4	21.615	2.5
6	21.615	2.2
0	23.365	0.9
2	23.365	1.3
4	23.365	1.6
6	23.365	0.8
0	25.115	0.9
2	25.115	1.2
4	25.115	1.4
6	25.115	1.5
0	26.865	1
2	26.865	1.6
4	26.865	2.2
6	26.865	2.4
0	28.615	1.5
2	28.615	2.4
4	28.615	4.2
6	28.615	5
0	30.365	1.8
2	30.365	4
4	30.365	7.2
6	30.365	8.3
0	32.115	2.6
2	32.115	6
4	32.115	7.6
6	32.115	7.9

Kungsholmsstrand – energy log

Energy consumption at different scenarios

Report, 2012-11-04

Purpose

The purpose of this document is to document energy consumption from Kungsholmsstrand at different scenarios. Also to document actions taken.

Scenario #0

Scenario #0 means:

- No power down of lightning.
- Power 10 (full power) all the time

The net consumption of just the LED lightning poles where measured 2012-10-04 by disconnecting all other consumers. The net consumption was 1035 W (30,5W / pole).

Average total consumption at high power, using mean values for the first days van be assumed to be 3795W. This means the power consumption besides our own poles are 3795 – 1035 = 2760 W. If subtracting this "besides consumption" value (2760 W) from power measurements below, then we can assume to have net power values for just the light poles.

Scenario #1

Scenario #1 means:

- High power 10 (full power)
- Low power 5 on "mid" poles
- Low power 7 on each 3 poles at the ends
- High power for 120 seconds after activation
- High power an all poles after activation

Scenario #1 set at 2012-10-07 -- 08

One of the end poles is difficult to reach by radio and will use high power all the time.

NOTE: Times given for all scenarios are UTC time. Scenario #1-#3 did run during daylight saving time and that means that 2 hours should be added for times given in table to get CET time.

Power measured:

Time (UTC)	Power (W)/Note
2012-10-07 16:19	Power on

Time (UTC)	Power (W)/Note
2012-10-07 17:00	3780
2012-10-07 18:00	3780
2012-10-07 19:00	3770
2012-10-07 20:00	3710
2012-10-07 22:00	3750
2012-10-08 22:00	3390
2012-10-08 23:00	3470
2012-10-08 00:00	3400
2012-10-08 01:00	3290
2012-10-08 02:00	3340
2012-10-08 03:00	3650
2012-10-08 04:00	3700
2012-10-08 05:03	Power off
2012-10-08 16:14	Power on
2012-10-08 17:00	3790
2012-10-08 18:00	3750
2012-10-08 19:00	3750

Time (UTC)	Power (W)/Note
2012-10-08 20:00	3710
2012-10-08 21:00	3500
2012-10-09 22:00	3580
2012-10-09 23:00	3320
2012-10-09 00:00	3410
2012-10-09 01:00	3310
2012-10-09 02:00	3520
2012-10-09 03:00	3540
2012-10-09 04:00	3690
2012-10-09 05:07	Power off
2012-10-09 16:16	Power on
2012-10-09 17:00	3790
2012-10-09 18:00	3790
2012-10-09 19:00	3800
2012-10-09 20:00	3740
2012-10-09 21:00	3520
2012-10-10 22:00	3530

Time (UTC)	Power (W)/Note
2012-10-10 23:00	3200
2012-10-10 00:00	3260
2012-10-10 01:00	3170
2012-10-10 02:00	3380
2012-10-10 03:00	3670
2012-10-10 04:00	3660
2012-10-10 05:06	Power off
2012-10-10 16:11	Power on
2012-10-10 17:00	3790
2012-10-10 18:00	3780
2012-10-10 19:00	3770
2012-10-10 20:00	3650
2012-10-10 21:00	3610
2012-10-11 22:00	3500
2012-10-11 23:00	3270
2012-10-11 00:00	3200
2012-10-11 01:00	3180

Time (UTC)	Power (W)/Note
2012-10-11 02:00	3270
2012-10-11 03:00	3530
2012-10-11 04:00	3720
2012-10-11 05:09	Power off
2012-10-11 16:10	Power on
2012-10-11 17:00	3800
2012-10-11 18:00	3790
2012-10-11 19:00	3790
2012-10-11 20:00	3790
2012-10-11 21:00	3660
2012-10-12 22:00	3460
2012-10-12 23:00	3450
2012-10-12 00:00	3580
2012-10-12 01:00	3360
2012-10-12 02:00	3510
2012-10-12 03:00	3690
2012-10-12 04:00	3740

Time (UTC)	Power (W)/Note
2012-10-12 05:12	Power off
2012-10-12 16:08	Power on
2012-10-12 17:00	3820
2012-10-12 18:00	3830
2012-10-12 19:00	3740
2012-10-12 20:00	3750
2012-10-12 21:00	3710
2012-10-13 22:00	3620
2012-10-13 23:00	3730
2012-10-13 00:00	3630
2012-10-13 01:00	3560
2012-10-13 02:00	3490
2012-10-13 03:00	3510
2012-10-13 04:00	3520
2012-10-13 05:14	Power off

Scenario #2

Scenario #2 means:

- High power 8
- Low power 5 on "mid" poles
- Low power 7 on each 3 poles at the ends
- High power for 120 seconds after activation
- High power an all poles after activation

Scenario #2 set at 2012-10-14

Energy and power measured:

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-15 15:32	3225410	Power on
2012-10-15 16:00	3227050	3480
2012-10-15 17:00	3230530	3500
2012-10-15 18:00	3234030	3480
2012-10-15 19:00	3237510	3490
2012-10-15 20:00	3241000	3350
2012-10-15 21:00	3244350	3360
2012-10-15	3247710	3310

Time (UTC)	Energy (Wh)	Power (W)/Note
22:00		
2012-10-15 23:00	3251020	3260
2012-10-16 00:00	3254280	3260
2012-10-16 01:00	3257540	3250
2012-10-16 02:00	3260790	3310
2012-10-16 03:00	3264100	3390
2012-10-16 04:00	3267490	3460
2012-10-16 05:00	3270950	
2012-10-16 05:32	3272840	Power off
2012-10-16 15:54	3272860	Power on
2012-10-16 16:00	3273170	3550
2012-10-16 17:00	3276720	3500
2012-10-16 18:00	3280220	3500
2012-10-16 19:00	3283720	3520
2012-10-16 20:00	3287240	3470
2012-10-16 21:00	3290710	3450

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-16 22:00	3294160	3350
2012-10-16 23:00	3297510	3330
2012-10-17 00:00	3300840	3360
2012-10-17 01:00	3304200	3320
2012-10-17 02:00	3307520	3330
2012-10-17 03:00	3310850	3380
2012-10-17 04:00	3314230	3420
2012-10-17 05:00	3317650	
2012-10-17 05:31	3319470	Power off
2012-10-17 15:46	3319490	Power on
2012-10-17 15:59	3320260	3480
2012-10-17 16:59	3323740	3500
2012-10-17 17:59	3327240	3500
2012-10-17 18:59	3330740	3500
2012-10-17 19:59	3334240	3500
2012-10-17	3337740	3420

Time (UTC)	Energy (Wh)	Power (W)/Note
20:59		
2012-10-17 21:59	3341160	3410
2012-10-17 22:59	3344570	3390
2012-10-17 23:59	3347960	3330
2012-10-18 00:59	3351290	3330
2012-10-18 01:59	3354620	3240
2012-10-18 02:59	3357860	3390
2012-10-18 03:59	3361250	3430
2012-10-18 04:59	3364680	
2012-10-18 05:37	3366870	Power off
2012-10-18 15:33	3366890	Power on
2012-10-18 15:59	3368440	3500
2012-10-18 16:59	3371940	3490
2012-10-18 17:59	3375430	3480
2012-10-18 18:59	3378910	3490
2012-10-18 19:59	3382400	3510

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-18 20:59	3385910	3410
2012-10-18 21:59	3389320	3370
2012-10-18 22:59	3392690	3320
2012-10-18 23:59	3396010	3420
2012-10-19 00:59	3399430	3350
2012-10-19 01:59	3402780	3320
2012-10-19 02:59	3406100	3390
2012-10-19 03:59	3409490	3410
2012-10-19 04:59	3412900	
2012-10-19 05:34	3414880	Power off
2012-10-19 15:36	3414900	Power on
2012-10-19 15:59	3416310	3550
2012-10-19 16:59	3419860	3540
2012-10-19 17:59	3423400	3550
2012-10-19 18:59	3426950	3550
2012-10-19	3430500	3490

Time (UTC)	Energy (Wh)	Power (W)/Note
19:59		
2012-10-19 20:59	3433990	3550
2012-10-19 21:59	3437540	3450
2012-10-19 22:59	3440990	3420
2012-10-19 23:59	3444410	3410
2012-10-20 00:59	3447820	3390
2012-10-20 01:59	3451210	3370
2012-10-20 02:59	3454580	3390
2012-10-20 03:59	3457970	3470
2012-10-20 04:59	3461440	
2012-10-20 05:33	3463420	Power off
2012-10-20 14:57	3463440	Power on
2012-10-20 14:59	3463580	3580
2012-10-20 15:59	3467160	3590
2012-10-20 16:59	3470750	3550
2012-10-20 17:59	3474300	3550

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-20 18:59	3477850	3550
2012-10-20 19:59	3481400	3530
2012-10-20 20:59	3484930	3510
2012-10-20 21:59	3488440	3480
2012-10-20 22:59	3491920	3480
2012-10-20 23:59	3495400	3450
2012-10-21 00:59	3498850	3460
2012-10-21 01:59	3502310	3440
2012-10-21 02:59	3505750	3460
2012-10-21 03:59	3509210	3440
2012-10-21 04:59	3512650	
2012-10-21 05:36	3514770	Power off
2012-10-21 15:26	3514790	Power on
2012-10-21 15:59	3516690	3390
2012-10-21 16:59	3520080	3390
2012-10-21	3523470	3340

Time (UTC)	Energy (Wh)	Power (W)/Note
17:59		
2012-10-21 18:59	3526810	3370
2012-10-21 19:59	3530180	3320
2012-10-21 20:59	3533500	3330
2012-10-21 21:59	3536830	3230
2012-10-21 22:59	3540060	3250
2012-10-21 23:59	3543310	3220
2012-10-22 00:59	3546530	3200
2012-10-22 01:59	3549730	3180
2012-10-22 02:59	3552910	3240
2012-10-22 03:59	3556150	3300
2012-10-22 04:59	3559450	
2012-10-22 05:28	3561050	Power off
2012-10-22 15:26	3561070	Power on
2012-10-22 16:00	3562940	3380
2012-10-22 17:00	3566320	3360

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-22 18:00	3569680	3350
2012-10-22 19:00	3573030	3350
2012-10-22 20:00	3576380	3340
2012-10-22 21:00	3579720	3240
2012-10-22 22:00	3582960	3200
2012-10-22 23:00	3586160	3230
2012-10-23 00:00	3589390	3120
2012-10-23 01:00	3592510	3130
2012-10-23 02:00	3595640	3180
2012-10-23 03:00	3598820	3270
2012-10-23 04:00	3602090	3280
2012-10-23 05:00	3605370	
2012-10-23 05:32	3607190	Power off

Scenario #3

Scenario #3 means:

- High power 10 (full)
- Low power 5 on “mid” poles
- Low power 7 on each 3 poles at the ends
- High power for 120 seconds after activation
- High power on 7 poles (3 + own + 3) after activation

Scenario #3 set at 2012-10-23

Energy and power measured:

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-24 15:31	3654210	Power on
2012-10-24 16:00	3655930	3670
2012-10-24 17:00	3659600	3670
2012-10-24 18:00	3663270	3700
2012-10-24 19:00	3666970	3630
2012-10-24 20:00	3670600	3590
2012-10-24 21:00	3674190	3290
2012-10-24 22:00	3677480	3170

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-24 23:00	3680650	3210
2012-10-25 00:00	3683860	3070
2012-10-25 01:00	3686930	3140
2012-10-25 02:00	3690070	3110
2012-10-25 03:00	3693180	3400
2012-10-25 04:00	3696580	3650
2012-10-25 05:39	3702570	Power off
2012-10-25 15:30	3702590	Power on
2012-10-25 16:00	3704350	3710
2012-10-25 17:00	3708060	3660
2012-10-25 18:00	3711720	3670
2012-10-25 19:00	3715390	3610
2012-10-25 20:00	3719000	3560
2012-10-25 21:00	3722560	3350
2012-10-25 22:00	3725910	3270
2012-10-25 23:00	3729180	3240
2012-10-26 00:00	3732420	3240

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-26 01:00	3735660	3230
2012-10-26 02:00	3738890	3220
2012-10-26 03:00	3742110	3440
2012-10-26 04:00	3745550	3580
2012-10-26 05:43	3751670	Power off
2012-10-26 15:27	3751690	Power on
2012-10-26 16:00	3753610	3690
2012-10-26 17:00	3757300	3620
2012-10-26 18:00	3760920	3570
2012-10-26 19:00	3764490	3570
2012-10-26 20:00	3768060	3420
2012-10-26 21:00	3771480	3490
2012-10-26 22:00	3774970	3330
2012-10-26 23:00	3778300	3160
2012-10-27 00:00	3781460	3160
2012-10-27 01:00	3784620	3200
2012-10-27 02:00	3787820	3130

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-27 03:00	3790950	3090
2012-10-27 04:00	3794040	3200
2012-10-27 05:44	3799570	Power off
2012-10-27 15:24	3799590	Power on
2012-10-27 16:00	3801670	3660
2012-10-27 17:00	3805330	3540
2012-10-27 18:00	3808870	3450
2012-10-27 19:00	3812320	3410
2012-10-27 20:00	3815730	3350
2012-10-27 21:00	3819080	3190
2012-10-27 22:00	3822270	3320
2012-10-27 23:00	3825590	3240
2012-10-28 00:00	3828830	3230
2012-10-28 01:00	3832060	3190
2012-10-28 02:00	3835250	3130
2012-10-28 03:00	3838380	3070
2012-10-28 04:00	3841450	3140

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-28 05:46	3847070	Power off

Scenario #4

Scenario #4 means:

- High power 10 (full)
- Low power 5 on “mid” poles
- Low power 7 on each 3 poles at the ends
- High power for 60 seconds after activation
- High power on 7 poles (3 + own + 3) after activation

Scenario #4 set at 2012-10-29

NOTE: Times given for all scenarios are UTC time. Scenario #4 did run without daylight saving time and that means that *1 hour* should be added for times given in table to get CET time.

Energy and power measured:

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-30 15:14	3946890	Power on
2012-10-30 16:00	3949580	3630
2012-10-30 17:00	3953210	3670
2012-10-30 18:00	3956880	3640
2012-10-30 19:00	3960520	3610
2012-10-30 20:00	3964130	3600
2012-10-30 21:00	3967730	3310
2012-10-30 22:00	3971040	3250
2012-10-30 23:00	3974290	3120
2012-10-31 00:00	3977410	3150
2012-10-31 01:00	3980560	3120
2012-10-31 02:00	3983680	3080
2012-10-31 03:00	3986760	3050
2012-10-31 04:00	3989810	3190
2012-10-31 05:52	3996000	Power off
2012-10-31 15:13	3996020	Power on

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-10-31 16:00	3998840	3680
2012-10-31 17:00	4002520	3680
2012-10-31 18:00	4006200	3640
2012-10-31 19:00	4009840	3660
2012-10-31 20:00	4013500	3570
2012-10-31 21:00	4017070	3470
2012-10-31 22:00	4020540	3260
2012-10-31 23:00	4023800	3180
2012-11-01 00:00	4026980	3080
2012-11-01 01:00	4030060	3050
2012-11-01 02:00	4033110	3050
2012-11-01 03:00	4036160	3070
2012-11-01 04:00	4039230	3260
2012-11-01 05:54	4045600	Power off
2012-11-01 14:58	4045620	Power on
2012-11-01 15:00	4045690	3620
2012-11-01 16:00	4049310	3650

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-11-01 17:00	4052960	3660
2012-11-01 18:00	4056620	3670
2012-11-01 19:00	4060290	3610
2012-11-01 20:00	4063900	3600
2012-11-01 21:00	4067500	3420
2012-11-01 22:00	4070920	3240
2012-11-01 23:00	4074160	3150
2012-11-02 00:00	4077310	3170
2012-11-02 01:00	4080480	3150
2012-11-02 02:00	4083630	3080
2012-11-02 03:00	4086710	3080
2012-11-02 04:00	4089790	3140
2012-11-02 05:00	4092930	3470
2012-11-02 06:13	4097140	Power off
2012-11-02 15:10	4097160	Power on
2012-11-02 16:00	4100150	3650
2012-11-02 17:00	4103800	3600

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-11-02 18:00	4107400	3520
2012-11-02 19:00	4110920	3530
2012-11-02 20:00	4114450	3480
2012-11-02 21:00	4117930	3450
2012-11-02 22:00	4121380	3410
2012-11-02 23:00	4124790	3270
2012-11-03 00:00	4128060	3250
2012-11-03 01:00	4131310	3290
2012-11-03 02:00	4134600	3230
2012-11-03 03:00	4137830	3130
2012-11-03 04:00	4140960	3080
2012-11-03 05:00	4144040	3150
2012-11-03 06:00	4147240	Power off
2012-11-03 15:21	4147260	Power on
2012-11-03 16:00	4149590	3590

Time (UTC)	Energy (Wh)	Power (W)/Note
2012-11-03 17:00	4153180	3560
2012-11-03 18:00	4156740	3510
2012-11-03 19:00	4160250	3470
2012-11-03 20:00	4163720	3480
2012-11-03 21:00	4167200	3410
2012-11-03 22:00	4170610	3370
2012-11-03 23:00	4173980	3310
2012-11-04 00:00	4177290	3390
2012-11-04 01:00	4180680	3340
2012-11-04 02:00	4184020	3240
2012-11-04 03:00	4187260	3190
2012-11-04 04:00	4190450	3190
2012-11-04 05:00	4193640	3140
2012-11-04 06:05	4197070	Power off