Interreg CENTRAL EUROPE

Dynamic Light

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WORK PACKAGE 2
DELIVERABLE D.T2.2.4

Guideline for urban planners | 05 2019

STRUCTURE

D.T2.2.4

GUIDELINE FOR URBAN PLANNERS

Joint documentation of partners' master plans for know-how-transfer to other municipalities - guideline for urban planners on how to implement dynamic lighting into the public lighting system.

This document is a guide to create a liveable, healthy and sustainable city using dynamic public lighting strategies and achieving best practice. By following this guide lighting designers, architects, municipal light planning, decision makers, owners of public lighting infrastructure will be able to determine how to implement a dynamic lighting strategy, what changes can be made in order to improve the liveability of the cities, reduce operating costs, improve the environment and improve the operation and performance of public lighting. This guide will also help in avoiding pit-falls, false efficiencies in public lighting.

INTRODUCTION

Public lighting system is the basic and essential part of every city as well as one of the main energy consumers. In order to stimulate the development and modernization of public lighting infrastructure, new measures and concepts in the direction of smart city concept need to be constantly developed and proposed.

The condition for the integration and implementation of dynamic lighting solutions is the current state of technology which has to be applicable for cities and smaller municipalities, reliable according to the life-time and financeable. For this best practice examples from the pilot actions of the project partners were summarized.

Following the guideline shows how decisions on lighting are made within the municipalities: how needs of the community are monitored, what the role of municipal strategic plans is, how municipality defines its priorities and what to do to move things from idea to decision. For this the public lighting databases/GIS systems and lighting master plans are crucial.

To make this process more practical a process chart serves as a summary and the lighting strategies developed during the project are summarized.

The need for standardizing the lighting systems with the aim of energy saving and avoidance of light pollution is high. That’s why formal and technical steps have been undertaken to initiate the adoption process of master plans regarding the dynamic lighting solutions as a main result of this project.

1. DYNAMIC LIGHTING IN LIGHTING MASTER PLANS

1.1. Decision Making

The realization of dynamic lighting depends essentially on how decisions on lighting are made within the municipalities: how needs of the community are monitored, what the role of municipal strategic plans is, how municipality defines its priorities and what to do to move things from idea to decision.

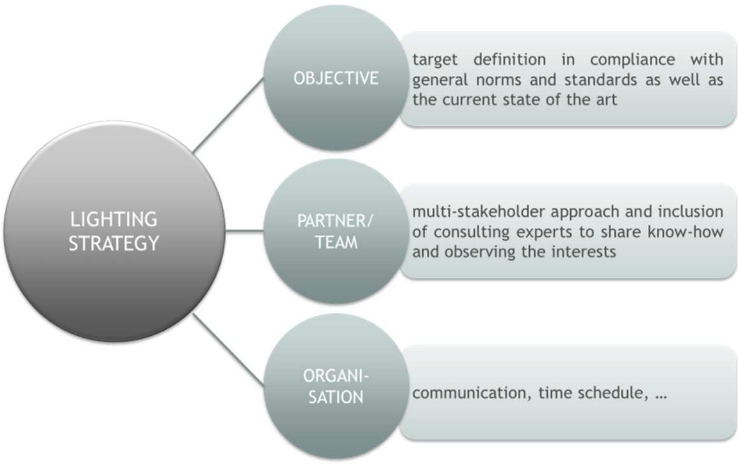

Figure 1: Target definition

For the implementation of dynamic lighting strategies, firstly, the targets have to be defined.

Based on the target definition it is important to involve who look for partners who support by reaching the target and fill the lack of know-how in special fields.

If the target is clear and the team is fixed, the work has to get structured and a timeline has to be defined. This seems to be simple, but this is a challenge, especially in the fixed structures of the administration.

In most cases, the cooperation with the participating offices of the city administration is necessary and the additional know-how of service providers and external lighting planner is helpful to fill the lack of knowledge. Furthermore a steering group for project control can be formed. The following figure shows as an example how the development of a dynamic lighting strategy can be build up:

Figure 2: Process-development of dynamic lighting strategies

1.2. Lighting Situation and Master Plans

In addition to the target definition and the organizational requirements the implementation of dynamic lighting is based on D.T 2.2.1 Analysis of the public lighting, D.T2.2.2 Strategies for city lighting and D.T2.2.3 Action plans for municipalities.

The following figure summarizes the in single steps worked on in Workpackage 3 to implement the pilot action. It can be generalized and used for further installations.

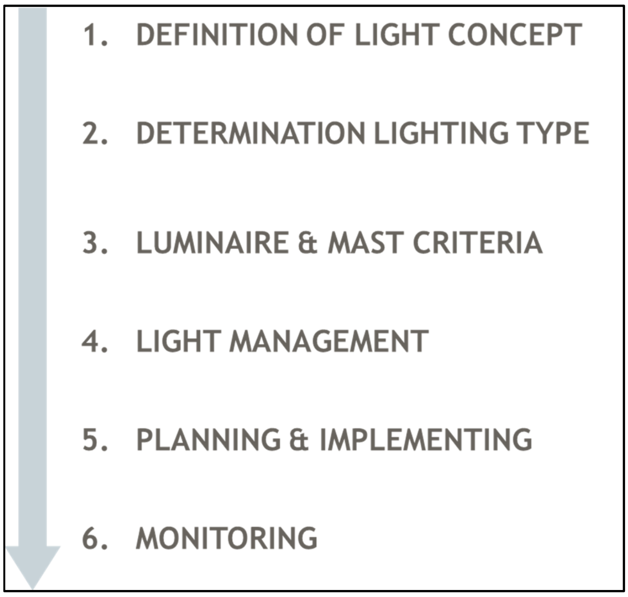

Figure 3: Guideline for City Lighting

Based on the structure of the urban space the lighting concept has to be defined. This goes in line with the determination of the luminaires and lighting type in dependence of the urban space.

To evaluate different luminaires and masts as well as to check if it fits with the internal regulation of the city, criteria have to be defined.

The next point is the light management, the form of lighting control to adjust the light intensity.

If the preliminary thinking process is finished, the realization process starts, which consists of the planning & implementing of the new lighting system.

To check the compliance and to evaluate the configuration of the systems, the process ends with the monitoring.

1.3. Light Managementand Forms of Dynamic Lighting

Related to the technological development light management makes different forms of dynamic lighting applicable:

- time dependent lighting
- presence dependent lighting
- bio-dynamic lighting

Starting with the existing forms of dynamic lighting, there are mainly three different lighting management levels which determine the selection and implementation of an adaptive lighting solution. The following figure shows an overview of the different solutions:

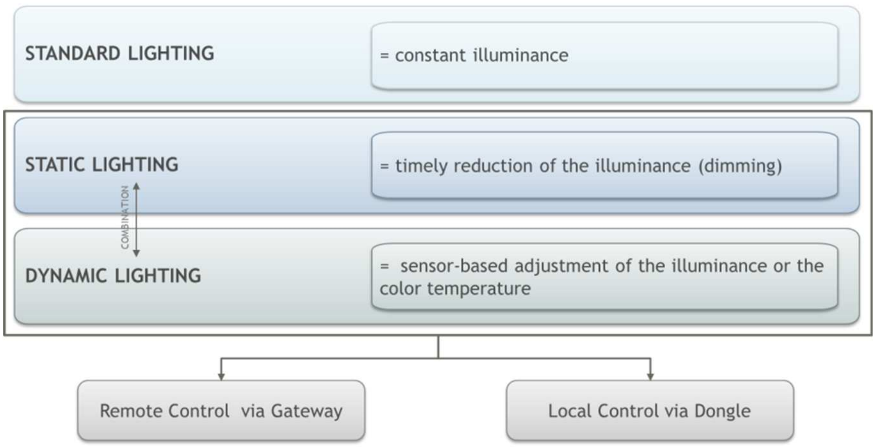

Figure 4: Forms of Dynamic Lighting

2. STATE OF THE ART TECHNOLOGY – BEST PRACTICE EXAMPLES

The condition for the integration and implementation of dynamic lighting solutions is the current state of technology which has to be applicable for cities and smaller municipalities, reliable according to the life-time and financeable (refer to WP 1 and pilots in WP 3). The chapter present an overview of dynamic lighting solutions that are already in use in European municipalities and show what dynamic solutions are particularly interesting for municipalities at the moment.

2.1. Čakovec, Croatia – Dynamic Lighting on Traffic Roads

Figure 5: Pilot Action Cakovec, Croatia

Pilot area in Town of Čakovec (Image 1. "Ring Čakovec") is determined by roads around the inner Town and includes all kinds of public transport. Total length of the corridor is approximately 2.71 km and it is consisted of six streets. The area is used for all kinds of activities like walking, jogging, casual sports, having fun, cycling and car driving. Pilot area surrounds the town center, the main square and park and connects all important streets in Town. Nearby is the city market, the majority of high schools and all important institutions and because of that it has high frequency of people and vehicles throught the day.

Since "Ring Čakovec" is placed at the inner Town (part of East and part of West Town district), important institutions, main bus/railway station and Town Square are placed nearby. Based on that, it can be stated that "Ring Čakovec" is highly used throughout the day by motor vehicles, pedestrians, cyclist and other users. Additionally, several times peer year Town Square is used for music concerts and other events.

Current public lighting in Town of Čakovec is switched ON/OFF on signal which is generated from central luxomat. Central luxomat is owned by HEP Elektra Čakovec (National Energy Company ltd.). In order to avoid infrastructure works (substations, control boxes, additional energy and communication cable laying), luminaires based on LED technology was installed on existing public lighting pillars. For the same reason, system for control and management based of wireless communication was implemented in "Ring Čakovec". New luminaires based on LED technology have advanced functions for district control and management. Detailed requirements for LED luminaires and System for control and management are be described in project documentation. In order to achieve dynamism of public lighting in "Ring Čakovec", LED luminaires and system for control and management have possibility of:

a) Control and management of individual luminaire, group of luminaires and all luminaires in real time. Intensity of light level and duration of it will be changed according to operator wishes. Pedestrian crossings and roundabouts will be lit all night.

b) Automatically change of light level according to weather conditions at sections of “Ring Čakovec”. Two weather sensors will be placed at “Ring Čakovec” in order to detect heavy rain and/or fog. According to weather conditions and sensors readings (decreased visibility because of rain and fog) level of light will be changed (increase or decrease) according to real condition on the field. New luminaires will be slightly oversized in order to achieve HRN EN 13201 conditions with specific (reduced) power of luminaires while the “reserve” power of luminaire can be used in case of weathering. Optimal regimes will be defined later on when performing the works. Specific power of luminaire will be determined when designing new public lighting.

2.2. Cesena, Italy – Upgrading Public Lighting in a Park Area

The investment was developed within the “Ex Sugar Refinery” area in Cesena and answer to the specific social lighting needs of the residents that was actively involved in the previous project task.

In particular the investment focused on a type of dynamic technology to adequate the light level on pedestrian paths, create a comfortable and pleasant atmosphere at night avoiding the light pollution.

The investment involved the following specific technical interventions:

11 September 2001 Park

- Removed of n.38 existing bollards lamps (mercury lamps-80 W)
- Extinguished of n.56 recessed luminaires (fluorescent lamps-18 W)
- Installed of n.28 new light points with LED type CREE LedWay Road, (absorption 37 / 12W - 3000K)

(with poles 4,5 m high) and equipped with dynamic motion sensors and presence detector.

C. Darwin Park

- Removed of n. 22 luminaires (high-pressure sodium lamps 70 W and mercury lamp 80 W)
- Installed of n. 22 new LED luminaries (with poles 4,5 m high) equipped with dynamic motion sensors Model CREE Ledway

The new lighting poles are equipped with occupancy sensors that use passive infrared (PIR) sensing technology that reacts to changes in infrared energy (moving body heat) within the coverage area. The sensors can detect the presence of pedestrians at 3 different distances (6m, 7 m, 12 m).

The pilot installation includes also the innovative web remote control system GESTART to monitor the system and to change sensor parameters such as high/low mode, sensitivity, time delay, cut off and more. This system will provide a flexible tool to adjust light output to the activity around each light point and, moreover, it will allow us to experiment and validate different dimming profiles. Different dimming profiles will be used to understand which one best suits people needs and will focus on the following main issue:

a) increasing light levels on pedestrian paths and concrete seatings;

b) assuring good horizontal and vertical illuminance;

c) creating a comfortable and pleasant atmosphere at night; d) ensuring a safe atmosphere.

2.3. Mantova, Italy – Bio-Dynamic Park Illumination

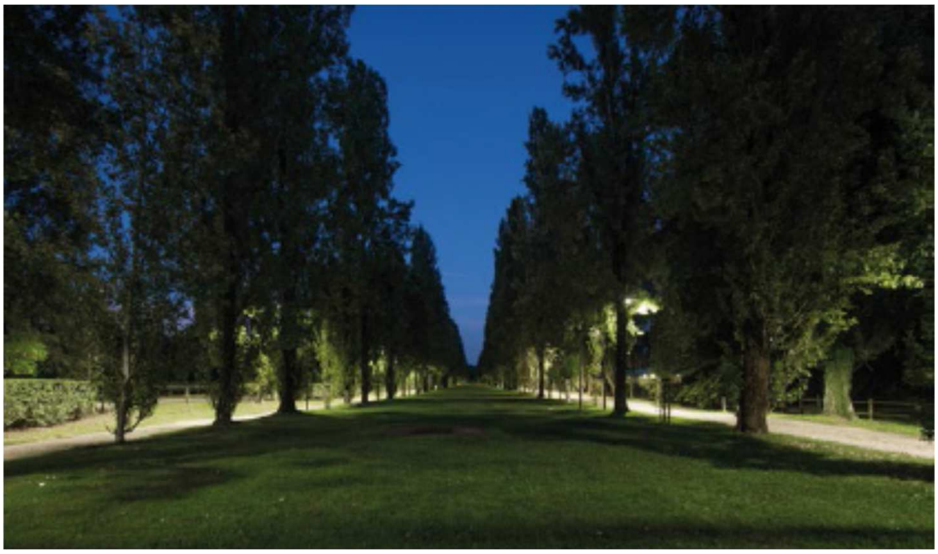
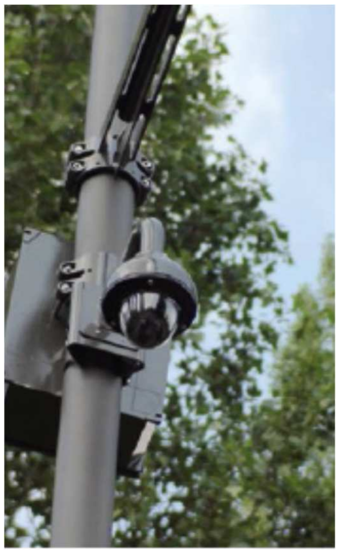

Figure 6: Pilot Action in Mantova, Italy

The pilot area is subject to direct protection, since Bosco Virgiliano has been declared as heritage of historic and artistic value with decree of Lombardy Cultural and Landscape Heritage Regional Directorate. Area's peculiarities allow the continual and accurate patrol by Law Enforcement and Parco del Mincio Voluntary Environmental Guards.

Once the area has been identified, a preliminary market analysis has been conducted, thanks to which technological partners, products and suitable technologies compatible with the installation have been tested and consequently validated.

The first investment concerns the lighting and electrical executive design, complete withspecialist technical report, report of photometric survey about current situation, design lighting simulations, electrical systems calculations and data sheets regarding identified components.

Furthermore, since the intervention area is subject to environmental, landscape and monumental restrictions, it has been necessary to apply for official Authorization from competent Government Department responsible for Archaeological, Cultural and Landscape Heritage, in order to be able to proceed with the lighting redevelopment of the pilot area and the Bio-Dynamic Light system implementation. Such report is accompanied by color photographic evidence, historic-artistic report, technical report, bill of quantities, general planimetries, geometric survey, material survey, static instability and/or structural deficiencies survey, materials conservation planning, planning of structural consolidation with architectural specifics, reutilization planning charts, comparative charts, design axonometric and perspective projection, historical-stratigraphic chart and plant design illustrative charts. Following the acquisition of the above-mentioned Authorization, the economic proposals related to all products and services identified as per project planning have been requested and collected.

Negotiation topics have been all components needed for the realization of the n.74 new light points and the implementation of the onboard Bio-Dynamic Light system. In this case:

- n. 60 "Full Cut-Off" Bio-Dynamic LED light systems, 2700 K ÷ 4000 K color temperature range, 22 W ÷ 30 W operating power range. Such light points will be installed on 6 meters above – ground poles, by means of 90 centimeters long specific arm at a 5,5 meters height;
- n. 14 "Full Cut-Off" LED light systems, 4000 K color temperature, 81 W nominal power, 58 W operating power. These light points will be installed:

- n. 6 on 6 meters above-ground poles, by means of 90 centimeters long specific arm at a 5,5 meters height;
- n. 8 on 7 meters above-ground poles, pole-top.

All implant poles (and both totem as well – ed.) will be installed by means of a new type of “screw” foundations with the lowest environmental impact possible. This mechanical support system of the pole, officially patented by a Spin-Off of Verona University, allows the drastic reduction of building infrastructures and related accessory works, introducing a foundations system alternative to the classic concrete plinth, in full compliance with current regulations and test parameters.

Successively, the Power-Line point to point remote control platform was identified, composed by:

- n. 1 concentration unity for management and remote control of switchboard and each light point, complete with GPRS/2G/3G modem;
- n.1 network analyzer module for surveying the electrical measures of switchboard and on-field elements;
- n.1 remote control module with DALI dimming interface for every light center.

The whole platform, as well as prearranging a network for future “Smart” implementations, will have the task to transmit through Power-Line communication the correct operating profile to each single light point.

With regard to Bio-Dynamic Light implant “direction”, it has been chosen to implement the system by means of n. 15 video cameras with onboard advanced analytics features. Each video camera is able to generate and output the compressed video flow and related metadata through an optical fiber infrastructure running along the whole path, making them available to the lights dimmering management system. The use of mere metadata allows to analyze and manage the information exploiting a moderate network bandwidth. The devices technical details and main features are the following:

- 1080p60 Resolution; ▪ Intelligent Video Analytics (14 onboard features);
- True Day/Night;
- 120 dB HDR Dynamic Range (Extendend Dynamic Mode);
- Simultaneous Hybrid, Analog and Video Over IP feature;
- 12V DC and/or PoE 7,2W power; ▪ -30/+55 °C temperature range;
- IP66 and Nema 4X protection level;
- Anti-vandal protection with IK10 impact resistance.

A control unity is installed to elaborate, thanks to a dedicated software and through appropriate algorithms, all the information received as metadata from the Video Analytics system and to send the commands for modulation and regulation of the lighting implant. The installed videocameras are interconnected with the controller through ethernet port, whereas the communication with lighting components will be carried out through TCP/IP.

In completion of the park technological redevelopment, two single-face and touchscreen multimedia totem will be installed at the two opposite main entrances.

For data sharing part, these devices will be both connected to the optical fiber network with appropriate devices. The installation of implant components and all accessory structural works will be performed by TEA Group subsidiaries, that means TEA Reteluce S.r.l., as regards electrical and lighting field, and Mantova Ambiente S.r.l., through its Green Spaces Service, as regards structural field and forest heritage protection.

2.4. Bled, Slovenia – Illumination of a Touristic Area

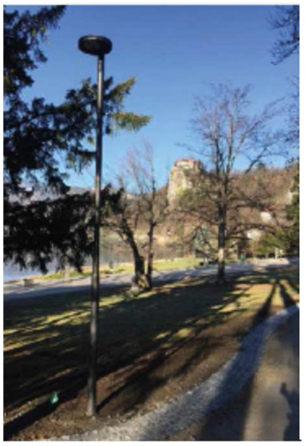


Figure 7: Pilot Action Bled, Slovenia

In Gorenjska Gora region 4 pilot areas in 3 different municipalities were identified. In municipality Bled two separate pilot areas were implemented, Park Vile Zora (pilot area 1) and green area under Park Vile Bled (pilot area 2). Bled is a town on Lake Bled. It is most notable as a popular tourist destination in the region and in Slovenia. Park Vile Zora is located on the eastern part of Lake Bled. It is situated between the municipal building on one side and the festival hall on the other. The area is therefore arranged landscape park, which is placed on the connecting area between hotels, shopping malls, restaurants, parking lot and a walking path around the lake.

The second location is situated in the park under Vila Bled. There lies connecting walking path that connects the existing regulated promenade of the touristic accommodation facility Vila Bled. Area is cultural and natural heritage so we need to ensure minimal impact of nature and thereby destroy the existing flora and ensure the safety and the intimacy of each user.

Pilot location in Municipality Tržič is a local connecting road within the Industrial zone Mlaka. Road is intended exclusively for motor traffic. Depending on the purpose of use in the area of illumination we can define that lighting need to ensure during night time adequate levels of illumination for the safety reason of transportation of cars and transport vehicles.

Last pilot location is regulated around the lake „Planšarsko jezero“ in municipality Jezersko, which is the highest located and smallest municipality in Gorenjska region with main focus in tourism. It is protected area, where we had to adapt the shapes of lamps and poles to the requirements of the Institute for the Protection of Cultural Heritage of Slovenia (state regulator in the subject area). Some lamps will be used for the purpose of cross-country skiing which area leads beside the road.

By using the motion-dependent light control, the light intensity is adapted to the real usage. During the night from 23-6h lights are switched off.

2.5. Susice, Czech Republic – Dynamic Spotlighting of a Historical Place

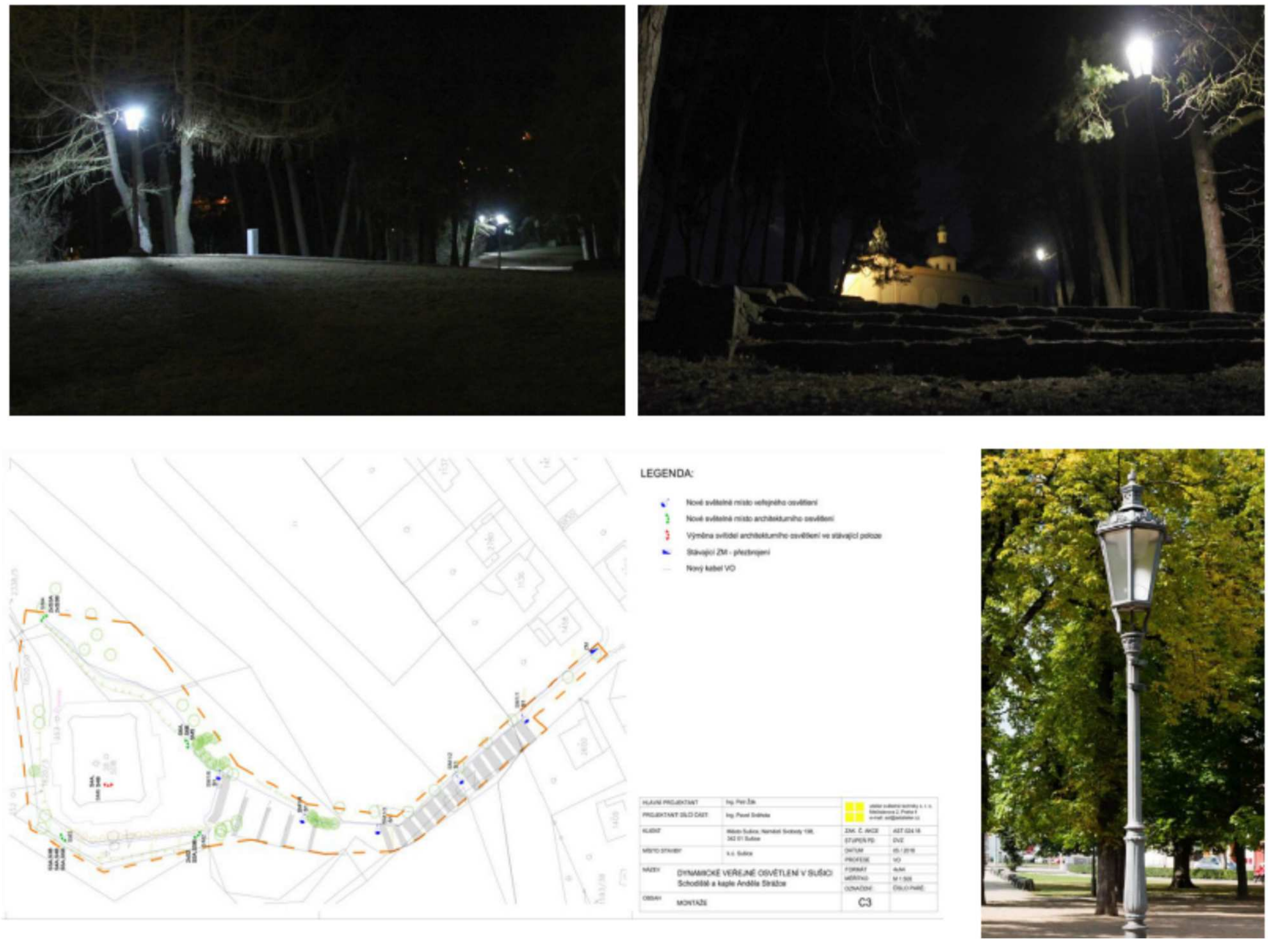

Figure 8: Pilot Installation Susice, Czech Republic

The dynamic lighting project includes the surroundings of the chapel of St. Angel the Guardian and the staircase from Alšova street right up to the chapel itself. The specificity of this location lays in the historical atmosphere and necessity of architectural lighting of the chapel (five architectural lighting fixtures are installed at the site of the chapel). The location is used exclusively by pedestrians. The whole concept of dynamic lighting of Kaple Anděla Strážce and its surroundings is designed in accordance with historic building preservation and ensures minimization of negative effects on environment. Energy consumption is reduce approximately by 443 %, thanks to better options for control, light distribution and LED technology, new lighting reduces the light pollution by 40 %.

In the process of modernization of the surroundings of the chapel of St. Angel the Guardian and the staircase from Alšova street, existing masts were removed to avoid failure in reaching the public lighting standards. The existing infrastructure was replaced by newly designed luminaires with LED technology (including dynamic control) leading to a significant reduction in the total installed power of the selected part of the public lighting in the pilot area. In addition to the classical modernization of public lighting, a new system for management and control of the public lighting were introduced which, among other things, was allow for additional savings in electricity consumption. The design of new public lighting and the introduction of the management system are fully aligned with relevant regulations. The road lighting class in the pilot area is defined in accordance with the Norm EN 13201-1.Class P5 public lighting for pedestrians with recommended minimum operating values of the quality of public lighting: Medium illuminance of the street surface - Em = 3 lx, Minimal illuminance of the street surface - Emin = 0,6 lx.

The solution concept is based on the possibility of changing the lighting parameters of both, the public and architectural lighting. The changes in lighting conditions of public lighting occurs on one hand based on centrally preset time modes, and on the other, based on information from motion sensors mounted directly on the masts. The level of illumination and the color tone of the light are variable parameters. The level of illumination varies according to the time mode and, for a certain period of time, also according to the presence of people (dimming strategy varies between 40% - 100% of maximum Em). The color tone of the light is changing according to the time mode. Both variables are also adjustable for architectural lighting. The setup of both parameters are not change overnight, but by days (a weekday, weekend, holiday) and by season. This ensures the change of atmosphere and perception of the chapel during different seasons. Continuous luminous flow control allows to give more plastic look to the object. Both, light levels and chromaticity temperature can be individually adjusted by increasing their level above normal operating levels with regards to the social and cultural events in the area. For public lighting, two operating modes are set with the following operating profiles:

- common:
  - 22:00 normal Em = 3 lx (60%)
  - 22:00 - 06:00, adaptive (presence) Em = 2 lx (40%), minimal (absence) Em = 1 lx (20%)
  - 06:00 - off PL, normal Em = 3 lx (60%)
- festive:
  - 22:00 maximum Em = 5 lx (100%)
  - 22:00 - 00:60 adaptive (presence) Em = 3 lx (60%), minimal (absence) Em = 2 lx (40%)
  - 06:00 - off PL. normal Em = 3 lx (60%)

For calculation of the electricity consumption we take festive PL of 20 days during the year and activation of sensors 10x in one night. During sensor activation the minimum time of operation at the level of adaptive lighting is tp = 15 min. The motion detection system is set up in a way that any movement detection on any sensor is set the required level of illuminance for all luminaires. Changes in the color tone of light in public lighting are independent of the operating modes and for defined time slots two levels of chromaticity are being used:

- evening / morning Tcp = 3.000 K On PL - 22:00 and 06:00 - Off PL
- nighttime Tcp = 2.200 K 22:00 - 06:00

The architectural lighting is used on all the outer facades of the chapel, the chapel tower and the three west towers of the cloister. The surfaces of the illuminated outer facade have two colors, white and pink. The white color has a reflection factor pB = 85% and pink pR = 62%. The following architectural lighting brightness values were selected for the facade surfaces and for the corresponding illumination (determined for white facades):

- western facade: Lm,w = 7.5 cd/m^2, Em,w = 30 lx
- eastern facade: Lm,e = 5.0 cd/m^2, Em,e = 20 lx
- southern facade: Lm,s = 3.0 cd/m^2, Em,s = 10 lx
- northern façade: Lm,n = 3.0 cd/m^2, Em,n = 10 lx

2.6. Rostock, Germany – Demand-based Illumination of a Cycle Path

As a part of the project participation of the Hanseatic and University City of Rostock a pilot plant was installed along the 800 m long pedestrian and cycle path to close the illumination gap between the two districts Groß Klein and Warnemünde.

In preparation of the implementation the use of the path was analyzed. With the help of a camera-based traffic count, an average of 900 users per day was detected. In the night hours it is much less. Nevertheless, there is a continuous use and light like it is needed will be reasonable. In addition, the path is surrounded by green area, which as another aspect why the use of dynamic lighting is a benefit in this area. Due to regulatory requirements an adaptive lighting solution should fulfill the user demands as well as the ecological and legal standards.

The investment contains the dynamic lighting control of the pilot plant, which makes it possible to provide light only when it is needed.

For the technical implementation all luminaires were equipped with a controlling unit for continuous dimming. Together with infrared sensors only the section in which people are moving will be illuminated brightly.

The luminaires have a basic brightness of 0 % or 10 %. If a pedestrian or cyclist is moving in the detection range of the sensor, the light intensity increases up to 100 %. The luminaires communicate with each other via radio circuit, so that they can pass on a signal to the neighbouring luminaires after the detection of a user. In the pilot every luminaire has four neighbors, two in both directions. If the user leaves the detection area of the luminaire, it reduces the illuminance after a time of 30 seconds.

For remote control of the luminaires, a gateway is attached in the switchboard nearby. The gateway connects the luminaires and combines the data in a web application from which every single luminaire can be configured.

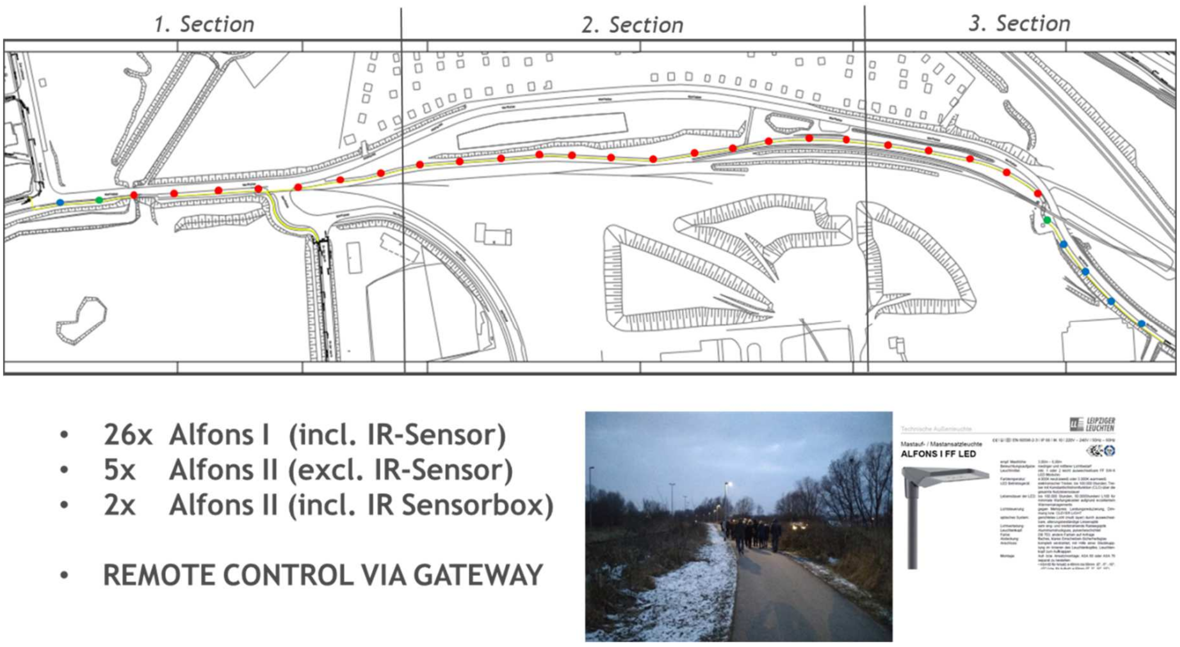

Figure 9: Pilot Installation Rostock, Germany

3. BENEFITS AND PROBLEMS

3.1. Benefits

The different pilot systems explained in the 2nd chapter describe different advantages which can be achieved by using dynamic lighting solutions. The main benefit is generated for the users. The possibilities to offer demand based illumination improve the use of public roads, parks and spaces during night hours.

Additionally the implementation of dynamic lighting technologies offers economical as well as ecological benefits, which are summarized in the following figure:

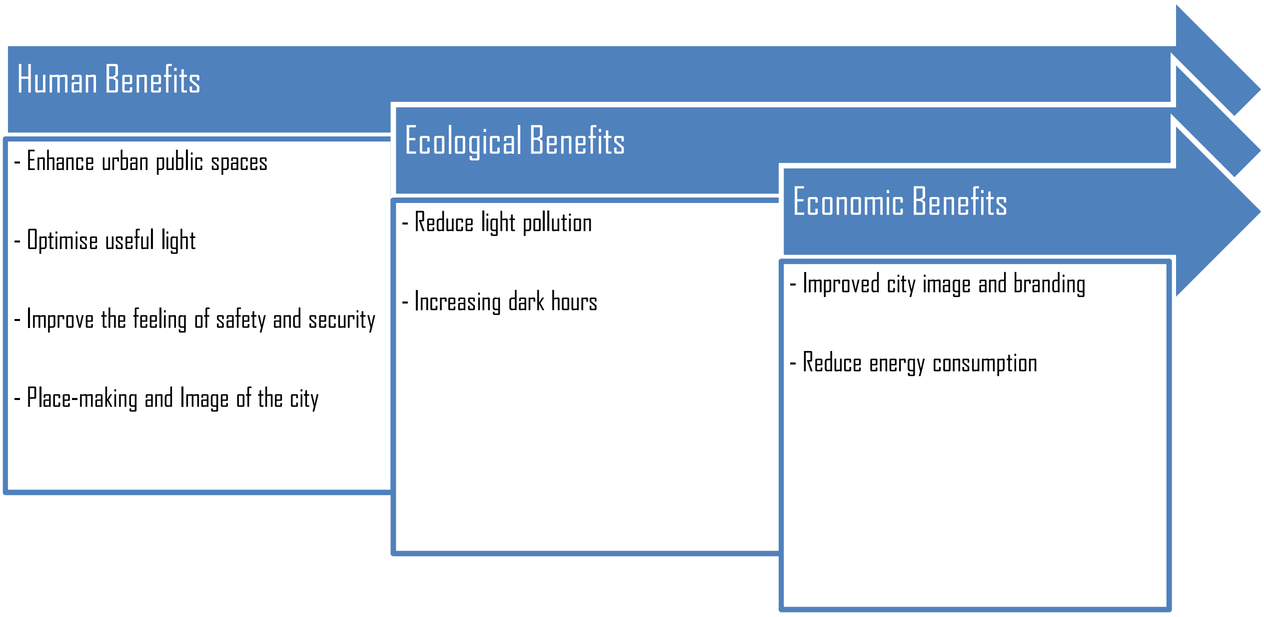

Figure 10: Human, ecological and economic benefits

3.2. Problems and obstacles

Knowledge and experts

The main challenge is the lack of knowledge on the subject. On the one hand there is a lack of qualified experts working in municipalities on the other hand the expertise of the companies providing such technology and installation of the same is questionable.

Communication

Difficult communication with the decision makers due to misunderstanding of the subject, makes it difficult to reach acceptance for new technologies.

Therefore one of the most important milestones of realizing dynamic lighting installation is the approval by the municipalities. That's why it is always very important that the investment is properly justified and all the benefits that it can bring to the town are well identified in advance.

Procurement and investment costs

Dynamic lighting brings many savings potentials. But the procurement process mainly considers the investment costs. Therefore it is important to compare as well the life cycle costs for dynamic lighting installations.

4. CONCLUSION

Dynamic public lighting should always start with a concept defining the basic requirements, characteristics and parameters the public lighting intends to achieve and a clear vision of the city's overall appearance including its key night-time landmarks. Therefore the merging of social demand, urban planning and lighting design is crucial.

A suitable lighting concept prevents the use of "dynamic" street lighting in city parts where either there is no need for it (e.g. higher class roads or the installation of sensors, motion detectors and the like on the streets where they completely lose their meaning) or in a totally unsuitable manner for the overall aesthetic character of the town (e.g. the use of unsuitable light color, chromaticity but also the light points themselves).

The implementation of pilot installations as an entry to the realization of further dynamic lighting projects helps to gain more acceptances. A good practice example can be replicated more easily.

Deciding on the implementation, however, is the communication. It is important to involve all stakeholders in the decision making process from the beginning.