Interreg
CENTRAL EUROPE
Dynamic Light

European Union
European Regional Development Fund

DYNAMIC LIGHT

TOWARDS DYNAMIC, INTELLIGENT AND ENERGY EFFICIENT PUBLIC LIGHTING, PROJECT OVERVIEW AND PILOT ACTION

CONTENTS

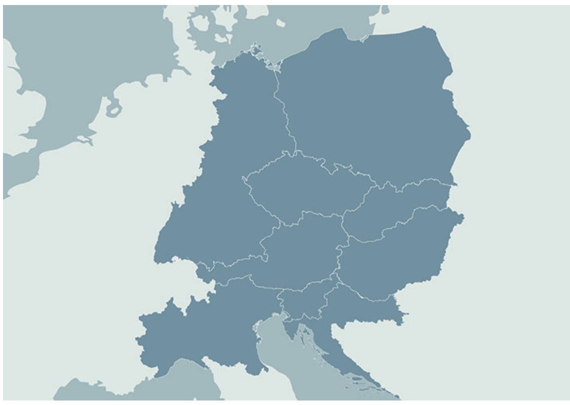
INTRODUCTION
ABOUT DYNAMIC LIGHT

Light at night enables us to experience and interact with the built environment; it establishes social spaces, spaces for interactions and exchange. It can encourage positive social behaviour and provide a safe movement.

Public lighting thus impacts not only our visual environment and functions, it influences flora and fauna, social interactions and behaviour, and of course energy consumption as well. Public lighting strategy therefore needs to simultaneously address the questions of light quality, ecology and energy. In turn, in order to do this, it is essential to understand the relationships and interactivity between the physical urban environment, the human being (user), and light.

The central aim of the „Dynamic Light" project is to establish and demonstrate the advantages of a proactive, adaptive or in other words a dynamic lighting strategy for public lighting. Improving lighting quality and energy efficiency means providing light in the future as needed, at the desired time, for the desired duration and for a specific target group. The core idea is that knowing and understanding people's needs, demands, expectations, and preferences is the key to a successful public lighting strategy and achieving environmental, economic and social sustainability. "Dynamic Light" is an EU funded research project involving 17 partners from seven different Central European countries, the various partners are cooperating in the project to investigate and evaluate typical lighting situations in the respective municipalities. The project has developed parameters for lighting control that reflect the social needs and demands of the user. These parameters have then been implemented across eight pilot installations across Central Europe. This will help in combining the technical aspects of lighting with the urban planning concerns in order to fully exploit the technological possibilities. At the core of these activities lies the aim to optimise the lighting design of public spaces by means of dynamic light to create liveable and useable urban spaces whilst reducing energy consumption, limiting light pollution and supporting a sustainable public space.

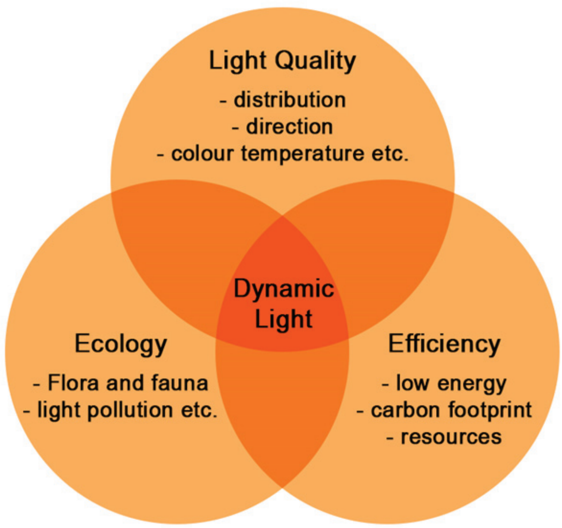
CHAPTER 1
DYNAMIC LIGHT IN PUBLIC SPACE



The myriad of possibilities offered by LEDs from the right amount of light, different light distributions, changing colour temperature to bringing light to where and when it is needed are now well and truly established. The true potential of the LED technology, however, lies in the use of intelligent control systems to control these various parameters of light. The control systems and strategies have for long been oriented towards energy efficiency alone. Though important such narrow-minded strategies often result in "false efficiencies". The primary objective of any lighting strategy is to fulfil the needs, demands and requirements of the users. Hence, the quality of light and control strategy is as much important if not more as energy efficiency.

Taking our cue from Sustainability principles (see Fig. 1.1), through the various studies and research we can establish the three goals or pillars for public lighting, namely:

1. Quality of light: light for visual performance and comfort, right light at the right time for the right function and according to the user.
2. Ecology: Suitable light for all ecological systems, lower light pollution, human centric lighting.



"LIVEABLE, HEALTHY AND SUSTAINABLE PUBLIC SPACE"

3. Efficiency: Energy saving, lower carbon footprint and lower consumption of resources.

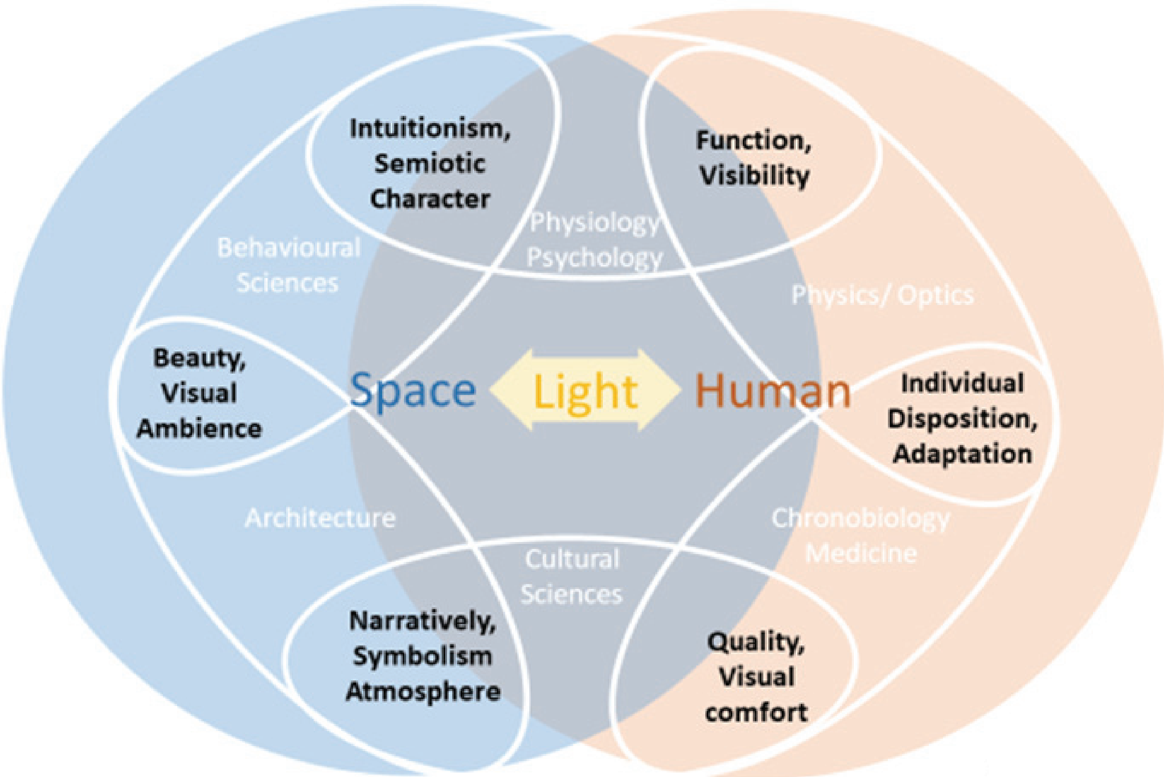
Adaptive lighting is more or less "a reactive lighting control". The lighting reacts to changes in time, change in volume, change in weather or change in ambient luminance; the sensors detect a change and the lighting reacts to that change in a pre-determined way.

Dynamic lighting on the other hand is "a Pro-active lighting control". Dynamic lighting is dependent on the user behaviour, user needs and demands. It is also the expected and desired lighting situation for a particular function, activity, time, user, place etc. Adaptive lighting is light adapted based on one or more parameters whereas dynamic light is the light adapted based on many parameters and respecting the user needs, demands and expectations.

This project lays the foundations for a better quality and manageability of lighting solutions and raising awareness about the user's needs and demands from public lighting. The project develops standards for lighting control (brightness, colour, light scatter, glare) that ensure the social needs of residents (security, visual identity, attractive urban areas, reduction of light pollution). The Dynamic Light project tests the performance of these parameters in different urban area types in order to adapt the technical standards and regulations for dynamic lighting and to exploit their previously untapped potential. The fundamental idea is that the technical aspect of the lighting needs to be combined even more strongly with questions of the city planning in order to use the existing technological possibilities.

The project connects the concepts of human needs and social demands with the technological and scientific possibilities, in order to implement dynamic lighting strategies. The project has been created to allow for an easy adaptability to various regions and countries. The individual regions and cities can very easily build upon the theoretical, technical and practical information contained in this manual and develop it to suit their particular requirements and technical capabilities.

The structure and contents of the project ensure long term usability. The flexibility of the outputs and tools allows them to be easily adaptable to various regions and territories. The project has also been developed independent of any manufacture or industry, allowing the various regions and partners to adjust the as per



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availability of technology and know-how.

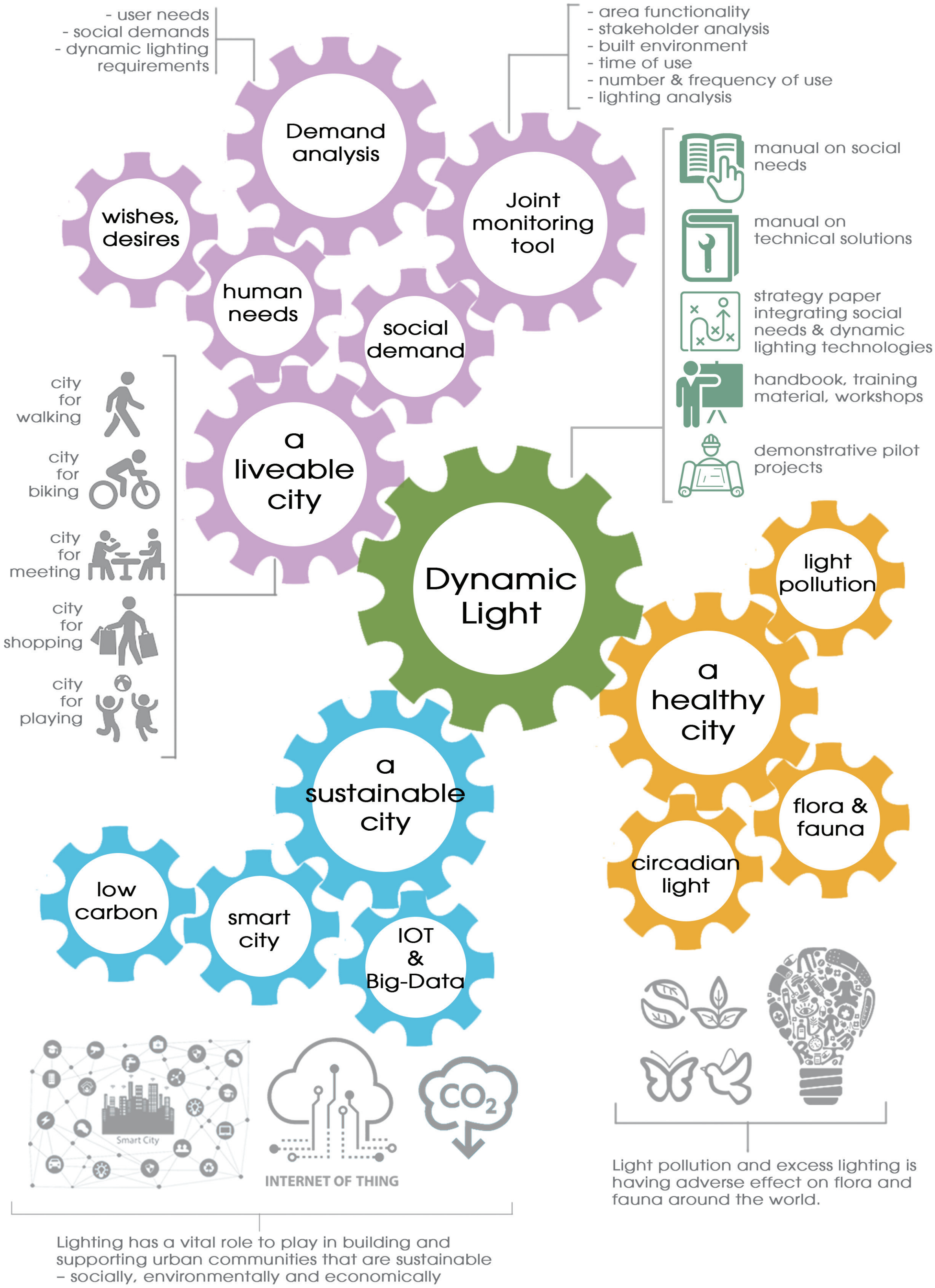
The project provides a set of tools, manuals, guidelines, action-plans and handbooks for urban planners, lighting designers, technicians, civic authorities, municipalities, energy and service providers from any region or territory, enabling them to develop dynamic lighting strategies for their particular region or territory or type of location.

Lighting for public spaces should establish social spaces within the night time urban landscape, observing and responding to the social interactions in the nocturnal city.

Dynamic lighting controls make public lighting truly multi-functional, performing different functions at the same time, being able to fulfil different requirements not only in long term but also short term, catering for different users, to name a few. Public lighting for the first time will be able to respond to even hourly changes in uses and not only long term changes. Let us have a look at some of the lighting parameters and how dynamic lighting controls can benefit.

Social and cultural infrastructure is essential to foster a sense of identity and belonging.

It is thus very important to develop a physical and visual atmosphere that provides the opportunity and the possibilities for healthy social interactions.


- user needs
- social demands
- dynamic lighting requirements
Demand analysis
- area functionality
- stakeholder analysis
- built environment
- time of use
- number & frequency of use
- lighting analysis
Joint monitoring tool
wishes, desires
human needs
social demand
manual on social needs
manual on technical solutions
strategy paper integrating social needs & dynamic lighting technologies
handbook, training material, workshops
demonstrative pilot projects
city for walking
city for biking
city for meeting
city for shopping
city for playing
a liveable city
Dynamic Light
light pollution
a healthy city
flora & fauna
circadian light
a sustainable city
low carbon
smart city
IOT & Big-Data
Smart City
INTERNET OF THING
CO2
Light pollution and excess lighting is having adverse effect on flora and fauna around the world.
Lighting has a vital role to play in building and supporting urban communities that are sustainable – socially, environmentally and economically

CHAPTER 2
THE DYNAMIC LIGHT TOOLBOX

The objective behind developing these tools is to provide Urban planners, municipalities, authorities, technical consultants with tools for understanding social needs, user demands and aspirations, technical possibilities, legal and financial opportunities and how these can be translated into dynamic lighting control strategies using the upcoming technology.

The following sections are divided into user, city and policies and legal aspects respectively. Each of these sections deals with a particular aspect of public lighting and its planning and implementation.

The section on user level will expand on the tools and manuals developed during the course of this project to ascertain user needs, demands, aspirations and requirements.

The section on dynamic light on city level will stress on the importance of transition to energy-saving intelligent public lighting solutions should be embedded in an overall urban lighting strategy and based on a clear understanding of the administrative and economic requirements for the deployment of these technologies.

Lastly, the section on policies and legal aspects This work package aims at developing standardised quality criteria for public lighting which include dynamic lighting and analysing lighting standards and norms in different countries to develop a strategy for inclusion of dynamic lighting. It also explores the legal and political framework to give recommendations for a legally secure implementation of dynamic lighting.

2.1. Dynamic light on user level

The city is a complex network of various political, economic and social environments – a mixing pot in which various different groups, cultures, classes, races, religions and communities constantly interact and grow. A lighting strategy for a city therefore needs to not only cater to the different individuals and groups but also encourage a positive and healthy interaction between the various groups and assist in the development of the different groups.

The chief goal of public lighting is to ensure the satisfaction of the various user needs. Knowing and understanding people's need and preference therefore is the key to a successful public lighting strategy.

Dynamic lighting controls with the ability to have precise light distributions, varying light distributions, on demand controllable light, colour, colour rendering, on demand illuminance and luminance levels, and integration of sensors and other services, will play a crucial role in satisfying the varying user needs and demands.

User Demands can be understood as multi-dimensional approach involving physiological needs, psychological and security needs. User Demands are the fundamental needs of an individual or a user group that enable the individual or a user group to carry out the essential functions and at the same time providing a comfortable condition.

Social needs can be described as the desires, expectations and aspiration for improvement in the urban fabric. These social needs can often encompass psychological and symbolic perception making them very difficult to quantify and describe.

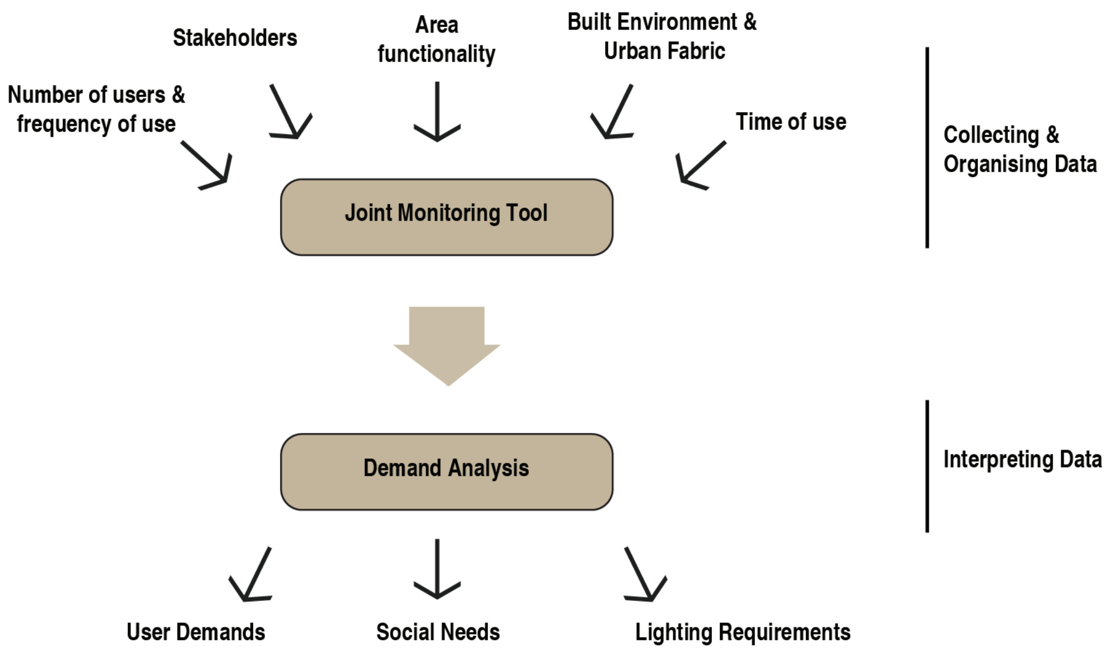
Public lighting Requirements: Through an understanding of "user demands" and "social needs" a set of public lighting requirements can be established. The user demands address the lower order needs like basic physiological and security requirements. The social needs then take care of higher order needs like social sustainability, sense of belonging, aspirations and expectations.

Tools for assessing User demands, Social needs: The complex inter-linked relationship between the needs, demands and society can be very difficult to measure, quantify and describe. To help create a set of requirements that can be easily understood and interpreted by the various stakeholders, we developed a set of tools to help in this process.

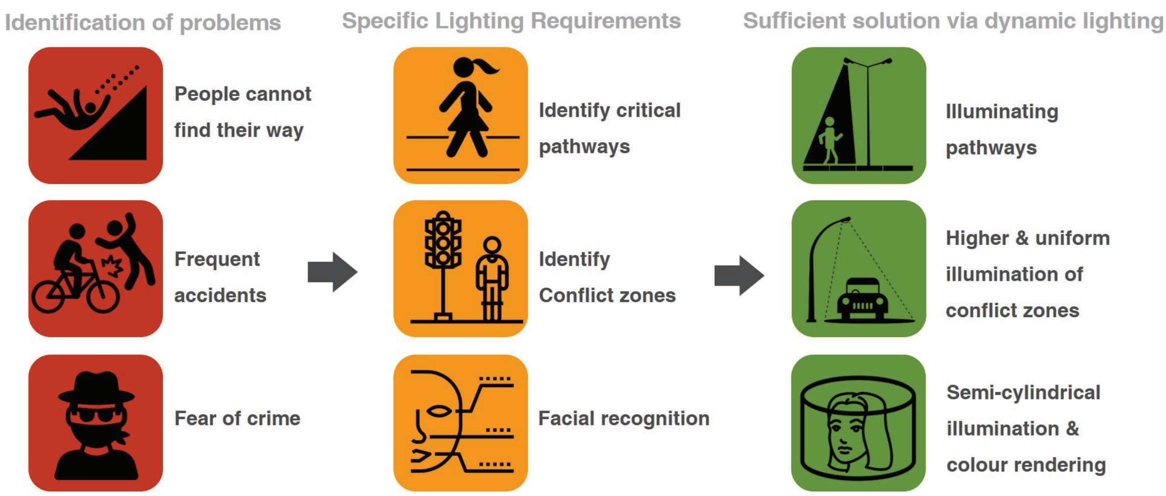
The joint monitoring tool is envisaged as an instrument through which the user's demand for dynamic lighting according to their social needs can be established. The monitoring tool consists of six components. Using these components, the important parameters can be established and investigated in detail to develop the dynamic lighting requirements.

1) Area functionality
2) Stakeholder analysis
3) Built Environment/ Urban Fabric
4) Time of Use
5) Number of users and frequency of use
6) Lighting analysis and conditions survey

Area functionality: Each activity has its own particular lighting requirement and demand. Walking, for example, requires good orientation and way finding, while on the other hand



shopping and meeting needs good colour rendering, inviting atmosphere amongst other requirements. Stakeholder analysis: Through the integration of stakeholders into the lighting plan, it can respond better to the context and users of the space. Built Environment/ Urban Fabric Light is reflected by the architecture and the built environment. Light makes the urban fabric, open spaces, walkways, squares etc. visible; where the activities and functions take place by the different users. Time of Use: The biggest potential for dynamic light is to understand that during the dark hours of a day the function of the space and the stakeholders are very different. Number of users and frequency of use All the people do not use all the public spaces all the time, users and frequency of use also changes as per the changing activities, uses and time in an urban space. Last but not the least it is very important to understand the existing lighting conditions. Does the existing solutions serve the various



functions, stakeholders, urban fabric etc. Does it respond to the changing requirements.

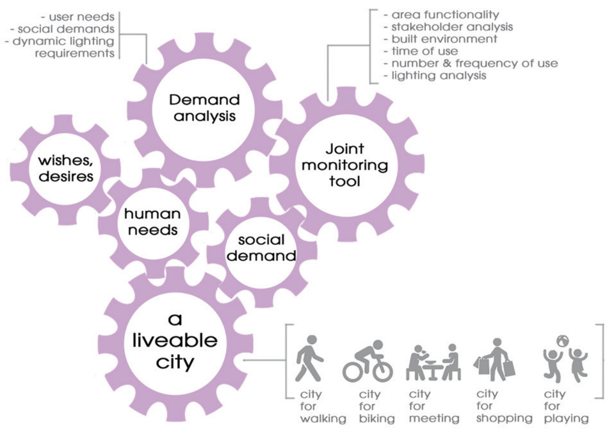
Demand Analysis develops a comprehensive demand analysis which will identify the dynamic lighting requirements of a particular site.

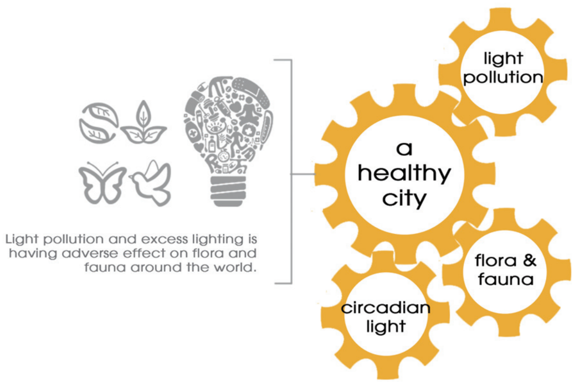
The liveable city, the healthy city and the sustainable city: These three general concepts combine the three main objectives of this research project, namely Quality, Ecology and Energy. The goal of a better public space puts a distinct and strong demand on the human dimension. There are direct connections between satisfying the user demands and social needs and achieving high quality public spaces.

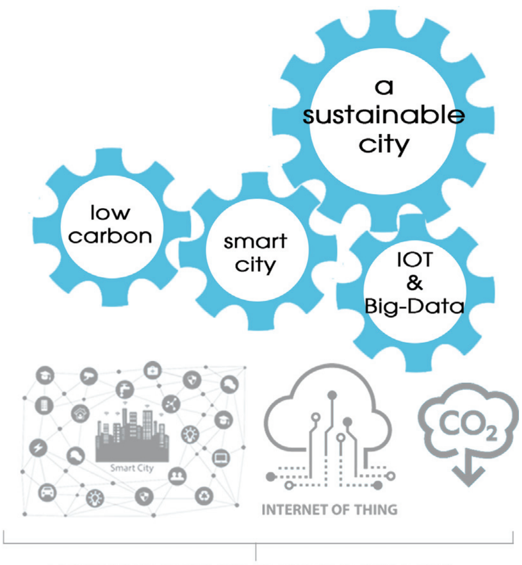
A Liveable city encourages life in public space, particularly the social and cultural opportunities as well as the attractions of a liveable city. The potential of a liveable city is strengthened when more people are invited to walk, talk, bike, stay, meet, play etc. in a space.

A Healthy city: Health here is not limited to the physical and mental health of humans but envelops health of flora and fauna and health of the environment in general, the underlying principle being the health of the ecology and different eco-systems.

A Sustainable city: Lighting has a vital role to play in building and supporting urban communities that are sustainable – socially, environmentally and economically [5]. Sustainable city results in a marked benefit to the economy and the environment, reduces resource consumption, limits emissions, decreases pollution levels etc. But more importantly a sustainable city also strives towards social sustainability.







Lighting has a vital role to play in building and supporting urban communities that are sustainable – socially, environmentally and economically

References:
[5] In the Shade: lighting local urban communities © 2012 Helen Hamlyn Centre for Design, Royal College of Art, Megan Charnley and Tom Jarvis

2.2. Dynamic light on city level

Providing services to city residents such as lighting of streets, footpaths and other public areas is one of the most important responsibility for city administration in terms of proper management and costs of energy and maintenance. In order to lower financial burden for the cities' budgets it is advisable to use a minimum amount of energy to deliver the required lighting for different areas and conditions. And this has to be carefully planned and consistently implemented.
There are three important aspects in streetlight management on city level:

-- Getting and managing information on street lighting system and its energy consumption, detected light pollution and quality of light;
-- Strategic planning of new lighting and retrofits to save energy and improve light quality;
-- Finding proper financing models for lighting investment.

GIS DEFINITION

A GIS is a system containing a spatial database representing aspects of a cultural and physical environment of a particular geographic region together with procedures for analysing combinations of attributes and generating graphical or statistical products

Source: Using Geographic Information Systems to provide better e-services. A guide for municipalities from Smart Cities

2.2.1 Getting and managing information

Implementation of methods to monitor performance, schedule systematic repairs and plan investments is highly required in street lighting management. Streetlights in towns operate in complex systems with large amount of light points and related technical and operational data to manage. This presents a considerable challenge for city lighting managers. When streetlights need to be mapped out and data systematized, Geographic Information System (GIS) is an excellent tool. Apart from giving precise locations and characteristics of the street lights, a GIS system is able to help local government determine their energy consumption, optimize the use of lights and plan maintenance, retrofits and new lights.

A geoinformation system enables to organise and use large amounts of data from many different sources. The first phase is designing a geodatabase to capture necessary information for the use in subsequent phases. In order to create a GIS streetlight platform which would be a comprehensive tool for efficient streetlight management and design, there is a need to identify data from the following categories: over which other, thematic information is placed
-- base data, i.e. map data over which other, thematic information is placed,
-- streetlight inventory data,
-- energy data for analysis of streetlight energy saving potential,
-- photometric data for spill light and light pollution analysis.

Streetlight inventory - attributes	
The Global Positional System (GPS) coordinates for each pole (luminaire)	Coordinate X: latitude
	Coordinate Y: longitude
Identification of responsibility for ownership of each luminaire	The owner of the pole and/or luminaire (Indicates which organization owns the asset): Municipality,ESCO, Private, Other
Identification of responsibility for maintenance of each luminaire	The manager of the pole and/or luminaire (Indicates which organization maintains the asset) Municipality, ESCO, Private, Other
Luminaire criteria	The type of luminaire: cobrahead, decorative acorn, decorative teardrop, etc.
	Lighting source: LED, Low P Sodium, High Pressure Mercury, High Pressure Sodium, Low P Mercury (C) Single, Metal Halide Lamp, Mercury Vapour Lamp, etc.
	Lamp power [W]
	Energy consumption per luminaire [kWh]
	Lighting controls: photocell, timer, etc.
Photometric data	Luminous intensity (l) [cd]
	Illuminance E- Lux[lx= lm/m^2]
	Luminance L[cd/m^2]
	Date of measurement
	Time of measurement
Pole and mounting criteria	The condition of the asset: e.g. excellent,very good,good,fair,poor,very poor,unknown
	The date the asset was installed
	The date the asset was renovated
	Height of street lighting column (pole) [m]
	The arm length of the light pole [m]
	Fixtures per pole
	Distance between poles [m]
	Lighting obstructions

In general, implementing GIS technology solutions can help to reach the three objectives:
-- Increasing energy efficiency of street lighting
-- Reducing light pollution
-- Decreasing maintenance cost of streetlight infrastructure

1. Increasing energy efficiency of street lighting

In order to improve energy efficiency of street lights, a current level of their energy consumption needs to be evaluated. Data such as the number of luminaires, types of lamps, the number of watts (W) used by each lamp type, the number of operating hours per each luminaire and the number of kilowatt hours (kWh) consumed by each lamp type allow to determine how much energy is consumed by the street lights in a certain period of time. With use of energy meters it is also possible to accurately measure energy use down to the level of each individual light point. Adoption of these data into GIS-based system enables street lighting managers to easily identify areas where street lights are inefficient in terms of energy use. This information can be used as a baseline for setting energy efficiency improvement goals. Energy consumption data plus other information retrieved from the GIS system, especially on zoning, specific functions of public areas, traffic volume, crime statistics, etc. enable grouping of lighting sections with respect to the energy saving potential and social needs as well as prioritization and rational planning of streetlight modernization projects. GIS technology offers solutions to relate lighting to the evening functions of a particular space as well as safety needs and provides a citizen-centered approach when implementing energy efficient and dynamic light solutions.

2.Reducing light pollution

Another goal is to decrease light pollution by finding over-lit areas, reducing light levels or switching off unnecessary lamps. With use of light meters and some fieldwork streetlight levels can be measured and implemented into the GIS system to create maps and identify under-lit places or areas where there is too much light during evening and nighttime. In this way a problem of spill light can be clearly demonstrated and light levels adjusted.

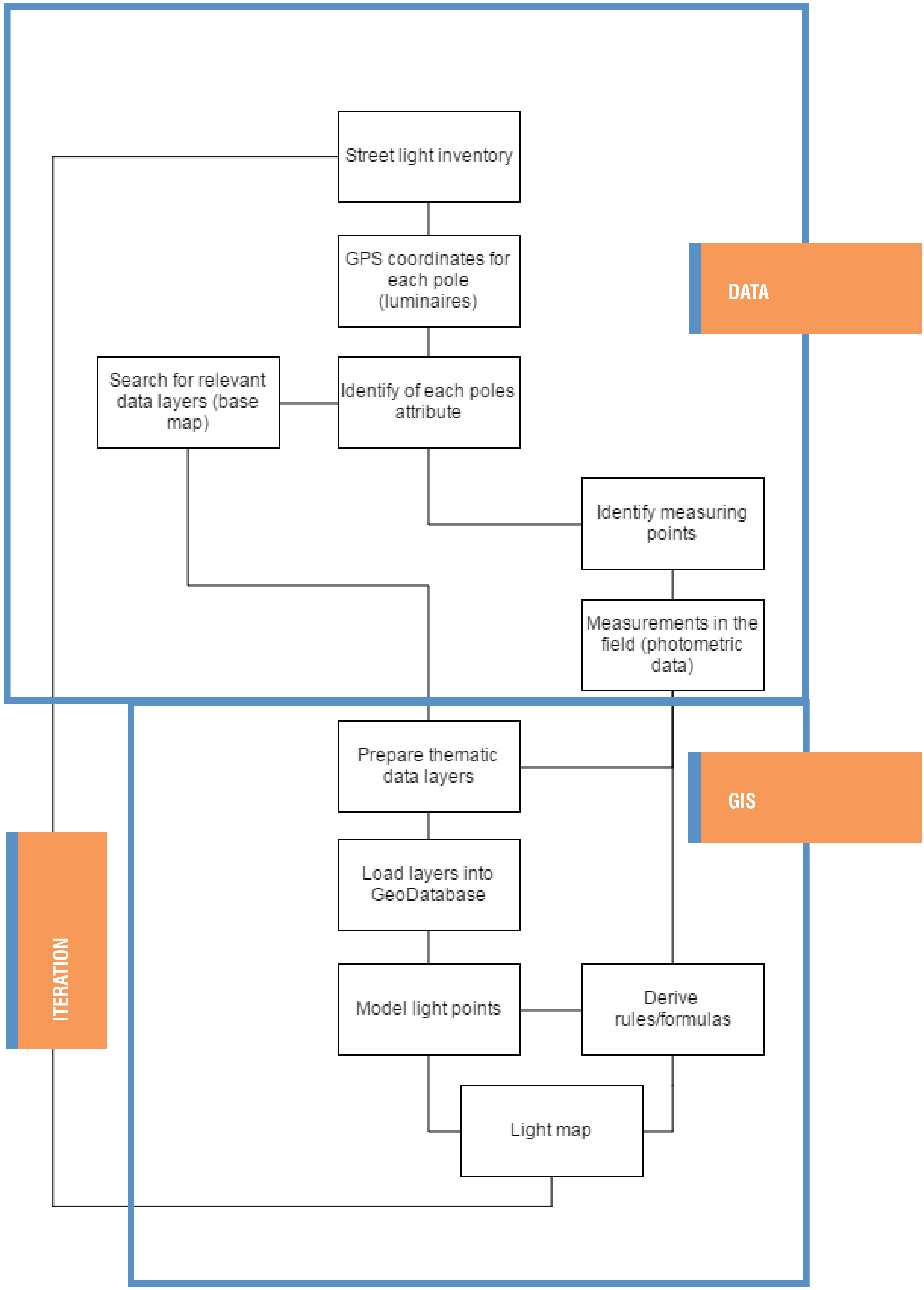
3. Decreasing maintenance cost of streetlight infrastructure

A GIS database of street lights enables proper maintenance and fast repairs of street lighting. By utilizing GIS system, a street lighting manager can get precise technical information at single pole location, making it possible to define exactly where future maintenance and repairs are needed. The age and condition of each lamp can be monitored and any failures can be reported by exact location. Moreover, the GIS-database enables to easily identify lamps that will soon burn out. Such systems offer the opportunity to significantly reduce maintenance costs by accurate planning of service.

WHAT IS LIGHT POLLUTION?

Light pollution is an unwanted consequence of outdoor lighting and includes such effects as sky glow, light trespass, and glare

Source: Lighting Research Centre



Street light inventory
GPS coordinates for each pole (luminaires)
DATA
Search for relevant data layers (base map)
Identify of each poles attribute
Identify measuring points
Measurements in the field (photometric data)
Prepare thematic data layers
GIS
Load layers into GeoDatabase
ITERATION
Model light points
Derive rules/formulas
Light map

2.2.2 Strategic planning

When the information on street lighting system is gathered and can be easily managed it is advisable to draw a strategy of public lighting development and develop relevant action plans. This will help to deliver and maintain a high quality of street lighting for the residents of a city throughout the coming years.
The strategy should have a comprehensive vision and key objectives that are linked to the vision. If a major consideration of the strategy are efficient lighting sources and innovative control techniques such as dynamic light systems, it should be clearly stated.

Steps that are needed to be taken to carry out the objectives while still fulfilling the vision are usually defined in city action plans. An action plan lists proposed actions and lays out:
-- What action will occur
-- Who will carry it out
-- When it will take place, and for how long
-- What resources (i.e., money, staff) are needed to carry out the action
-- Who will communicate the action to whom and how it will be communicated
The actions can be divided for short-term and long-term ones, and/or investment activities, education and information activities, administrative and organizational activities, etc.

The strategies of public lighting development and resulting action plans shall build upon the other relevant policies and strategies such as city development plans, smart city strategies, SEAPs, climate protection concepts etc. to reveal a general approach towards public lighting before defining the strategic objectives. Previous achievements should not be overlooked when planning new ones.

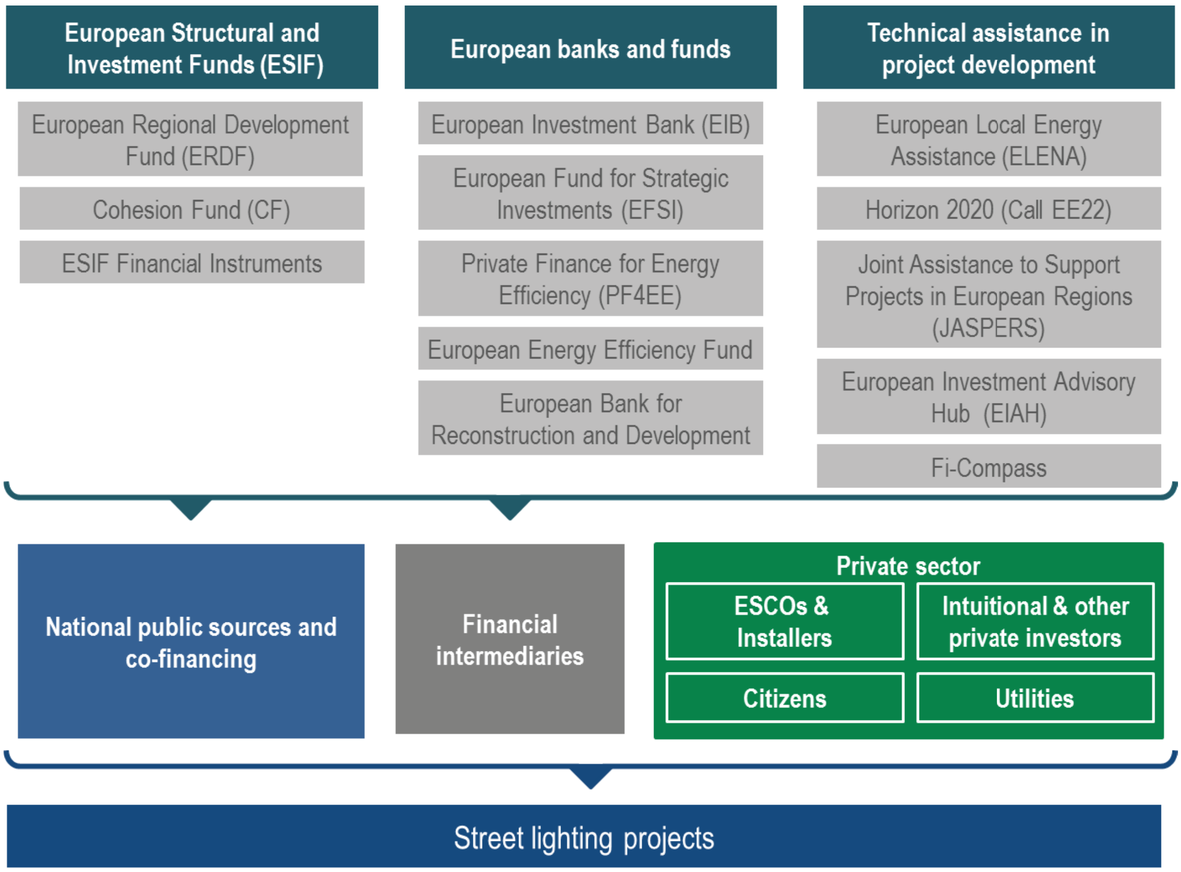
2.2.3 Financing models ----

Finding a suitable model for street lighting investment

Investment in energy efficiency upgrades of street lighting infrastructure significantly reduces energy costs and CO_2 emissions. It is also typically highly cost-effective and has a short payback period. In spite of these potential advantages, many areas of Central Europe have not taken measures to improve lighting infrastructure. Budgetary constraints on owners, which are often municipalities, are commonly cited as a reason for this inaction. Within Task 2.3 of the Dynamic Light project, the University of Greifswald, the Institute for Climate Protection, Energy and Mobility (IKEM), and SWARCO V.S.M issued a guideline, which help municipalities in Central Europe to identify a suitable financing models for street lighting retrofit.
We identified a range of opportunities that could provide the financing. These include EU funding and assistance programmes, national public funding sources, multi- and bilateral financial intermediaries, and private-sector funding as presented in Figure 1 below.

A number of EU funds and intermediaries could provide financing for preparation and actual implementation of the project. For instance, the European Structural and Investment Funds (ESIF) channel their resources to the Member States through operational programmes designed by each country according to its policy priorities. Its two funds, the European Regional Development Fund (ERDF) and the Cohesion Fund (CF), cover multiple energy efficiency measures, including street lighting. Furthermore, the European Fund for Strategic Investments (EFSI), Private Finance for Energy

Figure 1: Funding sources for energy-efficient street lighting in Central Europe



Efficiency (PP4EE), and the European Energy Efficiency Fund (eeef) managed and/or co-financed by the European Investment Bank (EIB) provided support for street lighting projects. The European Bank for Reconstruction and Development (EBRD) channels its support through credit lines to local commercial banks, which ultimately disburse funds to municipal lighting projects. in Croatia, Hungary, Poland, Slovakia, and Slovenia.

EU-funded technical assistance in project development is available through the European Local ENergy Assistance (ELENA) programme, the Joint Assistance to Support Projects in European Regions (JASPERS) initiative, and Horizon 2020 Project Development Assistance (Call EE-22-2016-2017). In addition, the European Investment Advisory Hub (EIAH) and fi-compass advisory service practical support, including expertise and skills training.

Each Member State uses ESIF funding to operate and co-finances multiple support programmes. Many countries offer additional options for support from the national and subnational budget, including grants or low-interest rate loans, and channel assistance through national environmental funds, national development banks, or other intermediaries (Table 1). Please consult Deliverable D.T2.3.2 for the information on eligible measures, beneficiaries and conditions for EU programmes and intermediary as well as information about national programmes.[1]

Table 1: Support programs for street lighting of the Member States in Central Europe

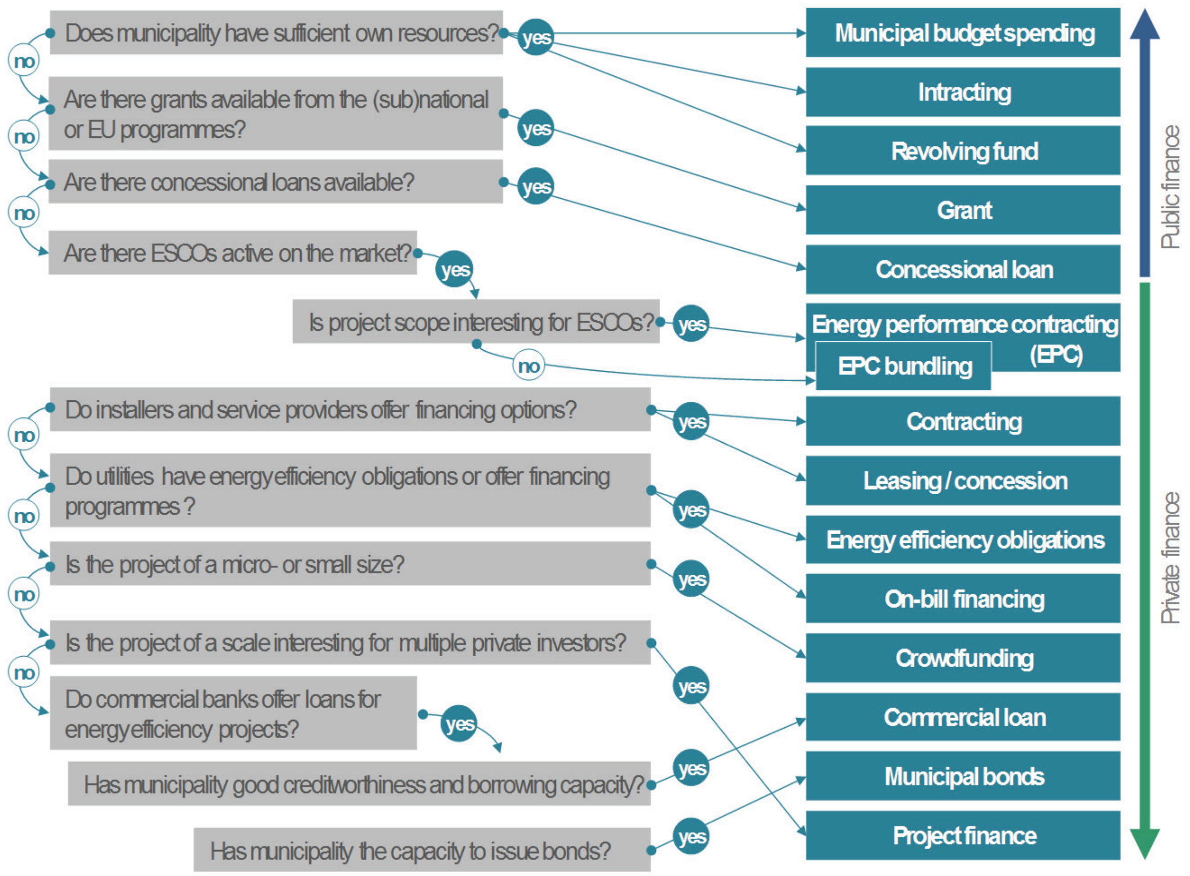
Austria · Programmes of the Climate and Energy Fund · Porgrammes “Energy Savings in Local Communities” and “Energy Savings in Industry and Commerce” · ‘Energie-Contracting-Programme’ of Upper Austria	***Croatia*** · Regional Energy Efficiency Programme for the Western Balkans · Green for Growth Fund Southeast Europe · Environmental Protection & Energy Efficiency Fund
Czech Republic · The National Environmental Programme · Programmes of the State Environmental Fund · Programme EFEKT	***Slovenia*** · Programmes of the Slovenian Environmental Public Fund · Programmes of the Slovene Export and Development Bank · Energy efficiency obligation scheme
Poland · The programme ‘Intelligent energy networks (smart grid)’	***Slovakia*** · SlovSEFF fund
Italy · Electricity generators and distributors are obliged to deliver energy savings from a range of measures, including street lighting, under the White certificate scheme	***Germany*** · Programmes of the Kreditanstalt für Wiederaufbau (KfW) · National Climate Initiative

Multiple private sources can also be utilised for financing street lighting projects. First, energy service companies and contractors that provide upgrades can finance the upfront investment costs, for example through energy performance contracting. In energy performance contracts (EPCs), municipalities repay the upgrade costs over time through energy savings. Second, in countries with utility obligation schemes in place, utilities finance street lighting upgrades and other energy efficiency measures in end-use sectors. Finally, municipalities can raise finances through crowdfunding and engage with institutional investors.

Furthermore, municipalities can establish a revolving fund to multiply available capital. A municipality invests capital (e.g., equity or debt) into a project (e.g., a street lighting upgrade). The project saves energy, which translates into energy cost savings that free up some of the budget resources previously used to cover utility bills. These funds, in turn, can be used to repay the initial investment and/or reinvest in new projects, thus creating a revolving model. The investment capital of municipalities could be blended with other, e.g. private sources of finance. Please consult Deliverable D.T2.3.3 details of private-sector financing models that could be suitable for financing street lighting projects. [2]

Figure 2 presents a decision-making tree to assist municipalities in selecting an appropriate financing model. Key considerations include the availability of public policies and funding, project size and bankability, the maturity of the market for energy service companies and energy service providers, the municipality's borrowing capacity, and the availability of financial instruments from commercial financial institutions. Please consult Deliverable D.T2.3.3 for more details on the decision-making process.[3]

Figure 2: Decision-making tree for selecting a financing model



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2.3. Policies and legal aspect

Facilitating the integration of dynamic lighting from a legal perspective

Implementing and upgrading public lighting infrastructure is a challenging process for all stakeholders involved. Moreover, implementing new technologies in the public lighting infrastructure raises complex legal, technological, and financial questions. The successful conversion of conventional lighting infrastructure to dynamic lighting solutions will require knowledge transfer and capacity-building among decision-makers and practitioners. This contribution of the University of Greifswald aims to address existing barriers to this transition process by providing a guideline to the implementation of public dynamic lighting infrastructure. It focuses on the experience of municipalities in Central European countries (namely Austria, Croatia, the Czech Republic, Germany, Italy, Poland, and Slovenia) that have installed public lighting infrastructure on a pilot basis as part of the Dynamic Light project.

Given the complexity of the public procurement process, a lack of capacities and knowledge regarding such process among decision-makers and practitioners is commonly cited as a significant barrier for promoting dynamic, intelligent, and energy-efficient public lighting. Especially the rules for (green) public procurement[1] are complex. Unlike private actors, public authorities may not freely choose their contract partners. The “Strategy to facilitate the integration of dynamic lighting from a legal perspective” (Deliverable D.T4.2.3) tackles this barrier by providing a guideline for implementing public dynamic lighting infrastructure. It refers to the experience of municipalities involved in the Dynamic Light project that implemented public lighting infrastructure, in pilot basis, financed by INTERREG Central Europe.

The implementation of dynamic lighting projects presents stakeholders with complicated technical and legal challenges. Smaller municipalities, in particular, may lack the necessary human-resource capacity and expertise in these fields. The rules for (green) public procurement are especially complex. Unlike private actors, public authorities must choose contract partners in accordance with set parameters. To prevent corruption and guarantee equal access of economic actors to public contracts, contracting by public authorities is governed by provisions of public procurement law. In EU countries, this legal field is complicated by the fact that it is primarily guided by provisions of EU law that are transposed by Member States into their respective national law. Relevant provisions therefore involve both EU directives and national laws.[2] Moreover, the implementation of a dynamic lighting project is a process involving many steps. The following subsections summarise the most important activities at each stage, from project conception to completion.

1. Where to start

A municipality interested in implementing a dynamic lighting solution must first assess its concrete needs and the goals that the municipality aims to achieve. In general, municipalities participating in the Dynamic Light project implemented such solutions to reduce energy consumption in public lighting infrastructure and thus lower their CO2 emissions. Nonetheless, dynamic lighting can provide other advantages as well. These include environmental benefits, such as the reduction of light pollution and negative effects on urban wildlife; social benefits, such as an improved quality of life from higher security standards and better urban aesthetics at night; and economic benefits, such as those due to a significant reduction in municipal energy costs.

2. Designing a project

Designing a dynamic lighting project constitutes an intervention in the public space. As a result, many aspects should be considered in addition to the technological requirements of public lighting. Important factors include the social needs of end users or beneficiaries, the environmental impact of the intervention, and the legal and regulatory frameworks that affect urban planning. Moreover, due to the innovative nature of dynamic lighting solutions, the municipalities seeking to implement such projects may lack the necessary human resources. Based on the experience of municipalities that have implemented such solutions on a pilot basis within the Dynamic Light project, it is advisable to develop synergies with private developers working in the field.

3. Procuring a contract

Municipalities in the EU must follow a very strict set of public procurement rules. Therefore, municipalities interested in implementing such projects will likely encounter the greatest challenges in the procurement stage. The EU has established a general framework on public contracts for its Member States. This framework provides a common legal basis for countries and municipalities within the EU.

Due to a lack of resources, public actors may seek external support for project implementation. Unlike private economic actors, which may choose a contract partner freely on the market, public bodies must comply with public procurement rules. These rules are intended to ensure transparency in public actors' choices of contractual partners and to avoid distortions of competition on a free market — an important consideration in light of the size of the public procurement market (15–20% of global GDP with an estimated volume of €1.3 trillion).[3]

Under public procurement rules, public actors are generally required to perform a tendering procedure to procure a contract. After the tender process, the public actor enters into a contract with the successful bidder. The provisions governing public procurement

1.In the following, the general term "public procurement" is used as an overarching concept for both public procurement and concessions contracts. For the distinction between public procurement in a stricter sense and concessions contract, see below under "Nature of the contract: public procurement or concession?".
2.For a description of the relevant legal framework, see Analysis of the political and legal framework and the examples (D.T4.2.2).
3.European Commission, DG GROW, "Public procurement", available at:
https://ec.europa.eu/growth/single-market/public-procurement_en (accessed 18 December 2018).

procedures are set by a complex set of rules at EU and national levels. A general EU framework has established a common legal basis for public contracts in Member States: the directive on public procurement[4] (hereinafter "PP Directive") and the directive on the award of concession contracts[5] (hereinafter "Concessions Directive"). Because these directives are transposed by national legislatures into the legal orders of the respective Member States, however, the specific design of public procurement rules may vary between EU countries.

Tendering is a complex process consisting in several steps that go throughout the procurement procedure and project life. Typical procedure stages for public procurements are: 1) Preparation and planning; 2) Publication and transparency; 3) Submission of tenders, opening and selection; 4) Evaluation award; and 5) Contract implementation[6].

4. Who must tender?

Both the PP Directive and Concessions Directive apply to procurement by "contracting authorities".[7] Therefore, all contracting authorities must comply by public procurement rules.

Contracting authorities are defined as "the State, regional or local authorities, bodies governed by public law or associations formed by one or more such authorities or one or more such bodies governed by public law".[8]

Bodies governed by public law are defined as "bodies that have all of the following characteristics:

(a) they are established for the specific purpose of meeting needs in the general interest, not having an industrial or commercial character;

(b) they have legal personality;

(c) they are financed, for the most part, by the State, regional or local authorities, or by other bodies governed by public law; or are subject to management supervision by those authorities or bodies; or have an administrative, managerial or supervisory board, more than half of whose members are appointed by the State, regional or local authorities, or by other bodies governed by public law". [9]

Entities that fall under these definitions must therefore issue tenders when necessary. In some cases, it may be unnecessary for a contracting authority to initiate a tendering procedure.

4.Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC, OJ L 94, 28.3.2014, p. 65–242.
5.Directive 2014/23/EU of the European Parliament and of the Council of 26 February 2014 on the award of concession contracts, OJ L 94, 28.3.2014, p. 1–64.
6.Source: European Commission (2018), Public procurement guidance for practitioners on avoiding the most common errors in projects funded by the European Structural and Investment Funds, available at https://ec.europa.eu/regional_policy/sources/docgener/guides/public_procurement/2018/guidance_public_procurement_2018_en.pdf (accessed 17 December 2018).

5. How to tender

A contract can be procured by a public authority under various procedures. In order to identify the appropriate procedure, the contracting authority must assess several elements that differ in accordance with the subject-matter of the contract. The nature and object of the contract determine the relevant threshold for procurement as well as the applicable procedure. The content of the tender and the criteria for awarding the tender are also conditional on the project concept. The applicable tendering procedure for public procurements is set by national law, regardless of whether the monetary value of the tendered contract lies above or below the thresholds specified in the PP Directive. For tendering contracts whose value falls below[10] the thresholds of the EU Directives, national law may prescribe specific procedures. In Italy, for example, a set of rules were issued for the procurement of contracts valued below the thresholds of the EU Directives; however, a direct award is possible for contracts whose value does not exceed €40,000.00.[11] Contracting authorities must therefore verify the relevant provisions set by national law.

For a detailed overview about the necessary project steps to implementation, as well as to legal challenges that may arise in the development of a dynamic lighting concept, refer to: Mercado, J., Martin, B., Marco, F. How to procure Dynamic Lighting projects A practical Guideline: Deliverable D.T4.2.3: "Strategy to facilitate the integration of dynamic lighting from a legal perspective". Report of the EU funded project "INTERREG Central Europe CE452 Dynamic Light", January 2019.

7.The Concessions Directive also refers to "contracting entities", these are however only relevant for the award of concessions in the energy, postal, or transport sector, which is not relevant to this report.
8.Art. 2 par. 1 (1) PP Directive; Art. 6 par. 1 Concessions Directive.
9.Art. 2 par. 1 (1) PP Directive; Art. 6 par. 4 Concessions Directive.
10.Art. 26 par. 1 PP Directive.
11.Art. 36 D. lgs. 50, 2016, G.U. n. 91 of 19 April 2016. The thresholds for direct awards were provisionally increased by act n. 145 of 30 December 2018 (contracts valued at €40,000.00–€150,000.00€ can be awarded directly prior to consultation with at least three operators).

CHAPTER 3
DYNAMIC LIGHT SOLUTIONS
——— PILOT ACTIONS

3.1 AUSTRIA --- GÜSSING

3.2 CROATIA --- ČAKOVEC

3.3 CZECH REPUBLIC --- SUŠICE

3.4.1GERMANY --- GLIENICKE/NORDBAHN

3.4.2 GERMANY --- ROSTOCK

3.5.1 ITALY --- CESENA

3.5.2 ITALY --- MANTOVA

3.6 SLOVENIA --- GORENJSKA

3.1 AUSTRIA --- GÜSSING

The castle of Güssing (Credit: Kultursommer Güssing)

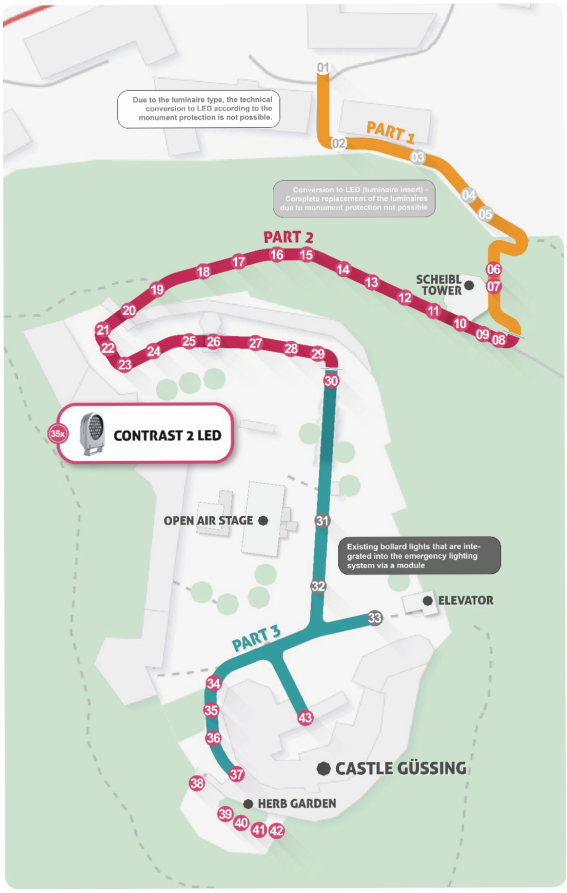
1.The Site

The site of the Dynamic Light installation in Güssing is the historic castle, situated on a long-extinct volcanic cone. Its steep cliffs rising from the plain and the plateau above the crater, as well as its location in the border area between Austria and Hungary were ideal conditions for the construction of a fortified castle.

The municipality of Güssing is the largest municipality in the ecoEnergyland. The municipality of Güssing intends to be a role model for the other municipalities in the region and also on national level for the implementation of efficient street lighting (as it was a role model for renewable energy implementations) and is always searching for new models and new technologies.

As Güssing has a special historical place in the middle of the town, which is the castle of Güssing, it tried to find a solution for an adequate illumination of the pathway up to the castle. As the idea of dynamic lighting was introduced to the municipality, it decided to realize such a concept and to develop a pilot project.

The focus of the pilot action is the path up to the castle of the city. For more than 20 years there is a special annual event on the castle, which is a special theatre, performed by the association "Cultural Summer of Güssing " in the spacious inner ward. For the visitors of the theatre, the way down from the castle always represented a challenge for the people, as the minor path lighting was not sufficient enough. Beside those thousands of visitors of the theatre, also hundreds of visitors from the city and region come each year and complained about the lighting situation up to the castle. Not only should the perceived safety of the ascend and descent be guaranteed, the realization of a



Concept for the lighting of the path up to the castle - including light points and sections - (Credit: EEE)

modern lighting concept using all the possibilities of current technologies and great savings potential is as important.

2.The Light

The state of lighting installations in the municipality of Güssing was already quite progressed in terms of energy efficiency. Based on an analysis in 2012 and the comparison to other municipalities, Güssing started initiatives to increase the efficiency of their public street lights, by replacing them step by step through modern LED lights. As of right now, more than a third of the public street lights are based on LED technology.

As the municipality of Güssing also realized a lighting system of the castle object itself, in a next step the discussions of the illumination of the path up to the castle were held. Güssing decided, that the lighting system of the path shall be something special, with an efficient and attractive concept behind.

This dynamic lighting concept of the castle in Güssing is divided into three main parts, according to the map.

The first part starts in the city center at the basilica and ends at the first gate of the castle. The main focus in this section lies on basic- and security illumination, to provide a safe and comfortable atmosphere in the formerly dark alley.

The second part includes the pathway from the first gate to the last gate before the top of the castle is reached. In this part it is particularly important that pedestrians always have a good visibility of the uneven and steep terrain, which is in addition necessary for a safe ascent to the castle and even more important for a safe descent at night. In addition, the walkway is illuminated by an indirect lighting with RGB LED spotlights, that are implemented at the walls beside the path of the castle.

The third part is situated on the top of the castle. The illumination is positioned beside the path to the open-air stage as well as beside the path to the herb garden on the backside and over the stairway to the main entrance of the castle. Also, the recreational- and assembly areas are illuminated to improve not only the feeling of safety but also provide a good orientation at night for the many visitors of not only the theaters, concerts, etc. but also the guest of the restaurant and the castle itself.

The new lighting is intended to create a harmonious and pleasant atmosphere in all areas, so that the visitors can feel safe and it increases the quality of life of the local population, in having one more attractive place to be visited safely day and night.

Modern outdoor lighting has undergone a particularly positive development in recent years, so that the choice of the most economical and efficient light source, especially with inclusion of regulation 09/245 / EC of the European Commission through its ErP Directive (2009/125 / EC, Ecodesign Directive) with defined specific requirements such as the required energy savings of at least 20%, fell on LED technology. For the lighting technology of the pathway, the Contrast 2 LED Lamps were chosen:

In the narrow paths, special attention had to be paid to the greatest possible glare-free light distribution through the appropriate light point height and indirect steering of the light onto the sidewalk.

The ability to mount this lamp in different ways on masts or in the rocky wall area facilitated the fulfilment of the requirements to reduce the photometric pollution and to protect the wildlife.

• A compact architectural floodlight range combining high output LEDs of predefined beams offering complete flexibility

• Innovative, compact design with integral gear for the medium and large sizes (static or dynamic versions).

• Exceptional modularity with LED colors, light distributions, accessories and light outputs in three body sizes

• Manual dimming on monochromatic versions and DMX controls on RGB versions for a variety of lighting effects

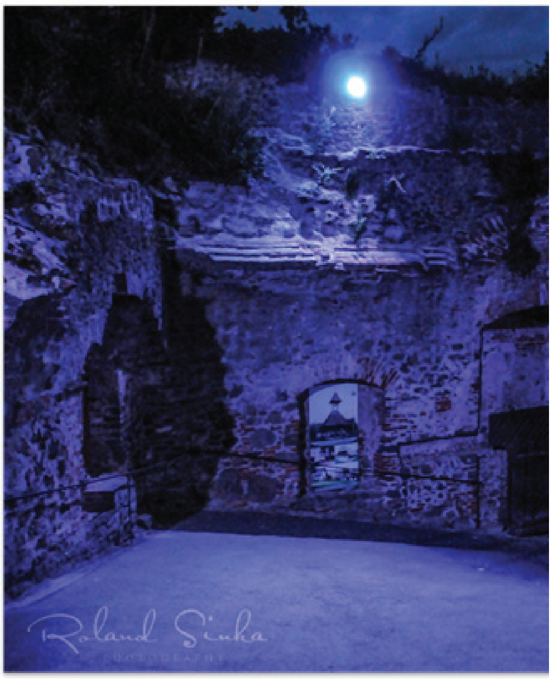
• Compliance of the regulations:

-- multiple sizes

-- powerful LEDs

-- various mounting options

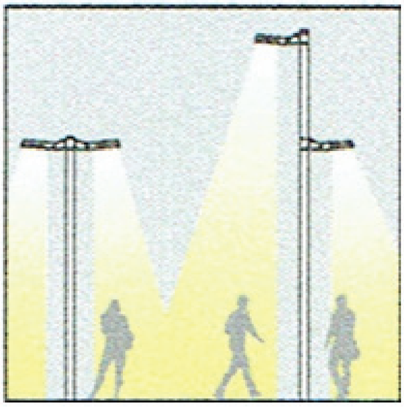
-- light distribution options even when using holographic filters

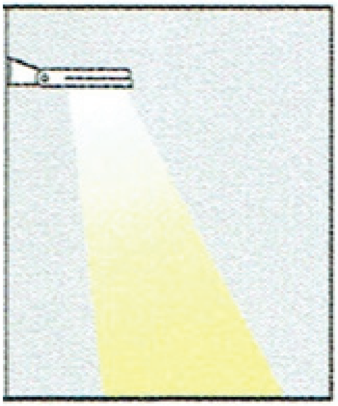


3.The Investment

The investment within the project amounts to € 52.568,68. The projected investment for the dynamic light system raises

Contrast 2 LED by THORN





the security level of the footpath and fulfills the public regulatory/standards, and also increases the attractiveness of the heritage for the touristic matter. The innovative technologies go hand in hand with requirements of heritage sites and show new solutions for other heritage sites in the whole region. As a positive side effect, energy savings and efficiency are also increased.

The castle of Güssing is owned by the public “Foundation of the formerly sovereign Prince Philipp Batthyány for the protection of the old castle of Güssing” with the shareholder Province of Burgenland. The path between castle and monastery is owned by the Castle Foundation and due to this fact it is also guaranteed that the maintenance can be managed.

4.Lessons Learned

The topic of the lighting concept was not just a technical challenge but also a social one. The project team as well as the town of Güssing had to act quite sensitive and will tried to respect doubts from local stakeholders and population as well as from tourists.

Those groups had to be integrated into the planning process to avoid conflicts after the implementation of the lighting system.

Apart from the groups mentioned above, the overall concept had to be developed quite sensitive in respect to nature and monument protection. Stakeholders from those sectors were also involved into the concept design and implementation of the system.

3.2 CROATIA --- ČAKOVEC

Pilot area in Čakovec - “Ring Čakovec”

1.Short introduction

Town of Čakovec is placed at north-west part of Republic of Croatia and it is cultural and political capital of Medjimurje county. Total administrative area of Town of Čakovec is 72,80 km2 while total population of area is 27.104. Administrative area of Town of Čakovec consist of Town of Čakovec and 13 suburban settlements.

Pilot action in the Town of Čakovec includes modernization process of road lighting infrastructure which is called “Ring Čakovec” situated in the city centre. Modernization of public lighting includes replacement of 160 existing luminaires (high pressure sodium technology) with 150 LED new ones in streets that are surrounding town centre (park, square, pedestrian and cyclist area). Apart from standard modernization of public lighting, weather condition sensors (rain, fog) and system for control and management of public lighting where installed.

2.The Site

Site selection, Integration in lighting strategy or Masterplan (Position and strategic value, Main stakeholders)

Based on conducted field survey of current state of public lighting and analysis of public lighting in two Town districts (part of West and part of East Town district), four locations where selected to be in contention for pilot area. Those locations are „Čakovec East“, „Čakovec South“, „Čakovec North“ and „Ring Čakovec“. In all of the mentioned area several characteristics were observed such as traffic volume of motor vehicles, pedestrian frequency, cyclist frequency, lifting attractiveness of historical buildings, proximity of the main bus/railway stations, town square, etc. Based on the valorisation of all of the above-mentioned characteristics and more, the area “Ring Čakovec” has been selected as a pilot area in this project. Total length of “Ring Čakovec” is approximately 2.71 kilometers and consists of six streets: Otokar Keršovani Street, Vladimir Nazor Street, part of Vukovar Street, part of Zrinsko-Frankopan Street, Toma Masaryk Street and Eugen Kvaternik Square.

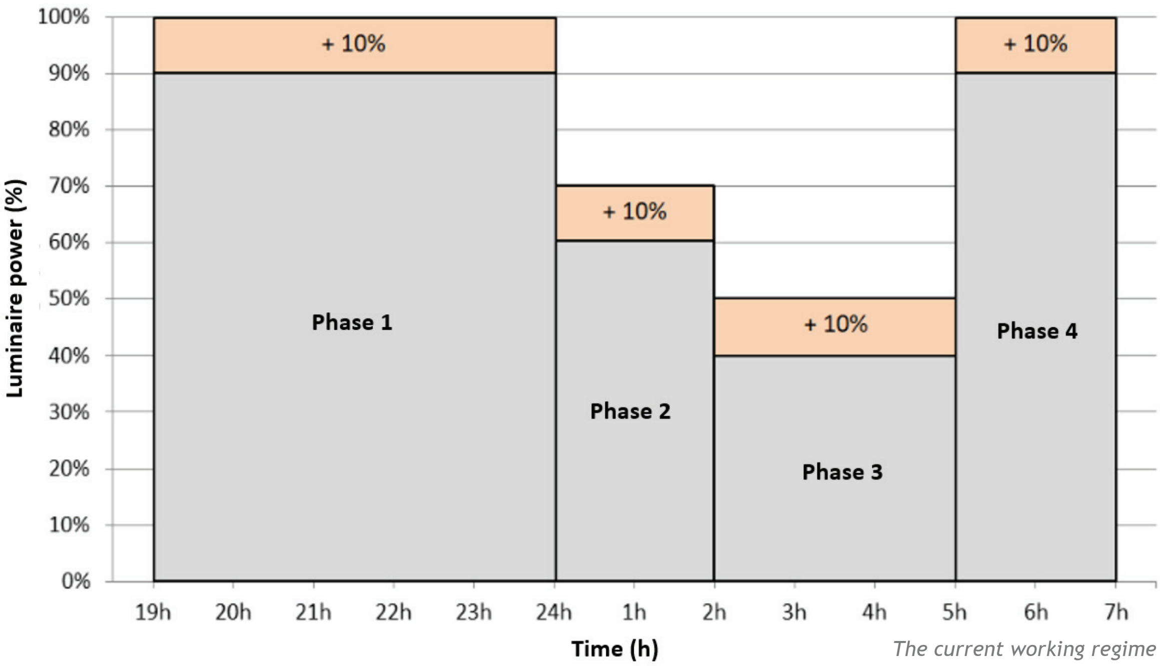
The area is a combination of residential, commercial and combined buildings as well as partly a park area. Near the pilot area there are several schools, both primary and secondary as well as kindergartens. Stakeholders who are using the area are residents, children and young adults (kindergarten and school age), office workers, municipal authorities, shop owners and other. Considering that "Ring Čakovec" surrounds inner Town and connects all kinds of important institutions, majority of stakeholders usually use area only to reach the target destination. Stakeholders mostly use motor vehicles, bicycles or are just using pedestrian lanes for walking or passing by.

The Town of Čakovec did not have any kind of strategic document developed that would deal only with the public lighting. However, they have developed a Sustainable energy action plan (SEAP) which defined a measure "Modernisation of public lighting infrastructure using a LED based technology". It has been planned for the defined measure to be implemented from year 2016 until 2020, to cost 1.3 million euro and finally save 660 MWh of energy and reduce emission of around 250 t of CO2. Prior to the implementation of activities through Dynamic Light project, an Energy audit of public lighting in Town of Čakovec has also been developed. Through the activities within this project both Strategy and Action plan for modernisation of public lighting in the Town of Čakovec were developed.

3.The Light

Lighting characteristics and technical approach, Contribution to sustainable development

In order to satisfy national legislative and norms which refer to the public lighting standards, the existing 160 HP sodium luminaires were replaced with 150 luminaires based on LED technology. Old luminaires had the power from 250 W to 500 W and the new LED ones have from 120 W to 160 W, which reduced total installed power in the pilot area from 58,23 kW to 19,86 kW and the annual consumption of electricity from more



The current working regime

than 238,000.00 kWh to a bit over 81,000.00 kWh. With the reduction of the consumption of electric energy, there is also noticeable decrease of the emission of CO2 – from almost 90 tCO2/a before the investment to 30 tCO2/a after the investment.

The lamps that were installed in the "Ring Čakovec" pilot area are Schreder Axia 2.2 and the control and management system is OWLET IoT. There are 67 luminaires with the power of 160 W, 75 with the power of 130 W and 8 with the power of 120 W installed. Their luminous efficacy is ≥90 lm/W for the 160 W ones and ≥ 110 lm/W for 130 W and 120 W ones while their impact resistance (IK) is 08 and degree of moisture and dust protection (IP) is 66. The working temperature of the selected luminaires is from - 25°C to 35°C. New LED luminaires where placed on current geometry of lighting poles in order to avoid additional infrastructure works (substation, control boxes, power supply cable laying, etc.) .

As for the control and management system, OWLET IoT is a cloud based platform which uses wireless communication between luminaires, sensors and the platform itself. The sensors that were installed react to the poor weather conditions such as heavy rain or dense fog. After testing several different possible working regimes, it was decided to obtain a working regime where the majority of luminaires work on 90% of installed power, while satisfying relevant lighting standards, until midnight (phase 1), then their intensity is lowered to 60% from midnight until 2 AM, from 2 AM until 5 AM the intensity is lowered further to 40% and at 5 AM risen back to 90% of power. The luminaires that do not change their intensity are the ones lighting up the

Old and new luminaires

Illumination of the street with new luminaires

roundabouts and pedestrian crossings, they work constantly at the nominal power. The intensity of the light is also changing when the weather conditions are poor (rain, fog, snow showers), i.e. it is risen to 100% for all luminaires.

4.The Investment

Ownership and maintenance (durability), Investment costs, return of investment

According to the Croatian law (Law on energy efficiency) the owner of public lighting, among others, has obligation to maintain and reconstruct public lighting infrastructure. Town of Čakovec is the owner of public lighting pillars and luminaires in the pilot area and therefore is paying invoices for energy consumption while maintenance of lighting infrastructure conducts subcontracted private company.

Apart from technical and legal framework, public procurement addresses the bails for new equipment and maintenance of the new lighting system in pilot area. According to the request in public procurement process, selected bidder has the obligation (on own expense) to eliminate potential malfunction of software – one year bail, and hardware components (luminaires, controllers, gateways) – five years bail. Selected bidder also offered 8 years of maintenance of the system for control and management. Maintenance of the system includes continuous support through preventive and corrective measures which improves operability of the whole system.

Total cost of the investment finally was in the amount of 79.816,66 € with included VAT and taking into the account annual savings of 18.500,00 €, simple period for the return of investment should be 4,3 years.

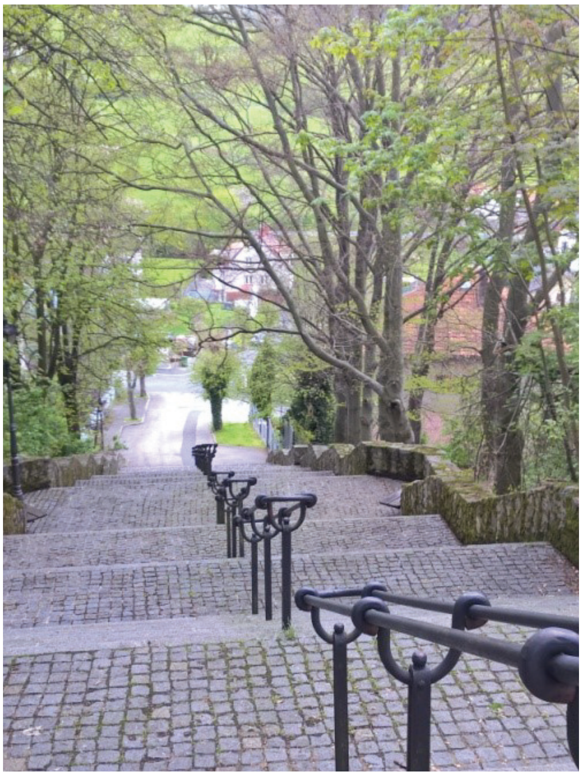
5.Lessons Learned

Transnational effect and added value

Realization of pilot investment in Town of Čakovec demanded lot of engagement in preparatory phase, coordination with external experts, creation of project and procurement documentation and controlling the implementation of works. While carrying out all mentioned activities it was necessary to use knowledge in different fields which needed to be constantly updated. Since partner consortium consist of partners who possess knowledge in different fields, it was necessary to keep in touch with them all and to get useful information and instructions for implementing certain activities. Now that the pilot investment is realized, it represents best practice example to whole partner consortium and points out main benefits but also obstacles in the whole process of realization the pilot investment.

3.3 CZECH REPUBLIC --- SUŠICE

Location (Street, city, country): Kaple Anděla Strážce, Sušice, CZE
GPS coordinates: 49.2351317N, 13.5270514E



1.Short introduction

The Town of Sušice lies in the Plzen Region and is often called the Gate to the Šumava Mountains, lies 465 m above sea level in the Svatobor Highlands. This former royal town spreads on both the banks of the once gold-bearing Otava River on the area of 16.6 square kilometers, and has about 11,500 inhabitants.
Within the framework of the Dynamic Light project, the area of the chapel of St. Angel the Guardian was chosen for realization.

2.The Site

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. In this location, there are 5 light points with different types of luminaires, Lucerna SHC (70W) and halogen (250W), where the overall level of illumination was insufficient due to a small number of light points.

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.

The objective of using dynamic control system and the associated renewal of public lighting in the proposed area was to improve lighting quality, to increase energy efficiency, to reduce light pollution and to verify the usefulness and impact of dynamic public lighting on the end-users. The investment contributes to a better atmosphere in the city center, increases tourist attractiveness and emphasizes the historical charm. In addition, the installed public lighting is be able to support a variety of cultural and other events organized by the city, thus not only increase the safety of these events (e.g. increase lighting levels at Christmas time, etc.), but also the aesthetics of the city (e.g. changing the color of lighting and the like).

Webpage:
http://www.porsennaops.cz/projekty-a-sluzby/mezinarodni-spoluprace/projekt-dynamic-light
Contact: Vítězslav Malý, maly@porsenna.cz, Vladimír Marek vmarek@mususice.cz

3.The Light

Lighting characteristics and technical approach, Contribution to sustainable development

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 (Orcave 401-550 software) 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.

3.1. Technical Data

	Before renovation	**After renovation**
Number of street lights:	5	5
Number of architectural lights:	3	6
Type of street lights:		
Manufacturer:	Pechlát (historical lamp)	Pechlát (renew historical lamp)
Power consumption of lamp:	70 W	37 W
Luminous flux of lamp:	N/A	2 100 lm - 2 400 lm
Type of architectural lights:		
Manufacturer:	N/A	iGuzziny
Power consumption of lamp:	250W (halide)	35 W
Luminous flux of lamp:	N/A	2 423 lm
Estimated Annual electricity consumption (kWh/year):	3 580 kWh	868 kWh
Control (monitoring) system:	None	Orcave
Medium illuminance of the street surface:	0,8 lx	3,4 lx (evening, morning time period)
Minimal illuminance of the street surface:	0,2 lx	0,9 lx (evening, morning time period)

3.2. The solution concept of dynamic control

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:

a) common: i) On PL - 22:00, adaptive (presence) Em = 3 lx (60%), ii) 22:00 - 06:00, adaptive (presence) Em = 2 lx (40%), minimal (absence) Em = 1 lx (20%), iii) 06:00 - off PL, adaptive (presence) Em = 3 lx (60%)

b) festive: i) On PL - 22:00 maximum Em = 5 lx (100%), ii) 22:00 - 00:60 adaptive (presence) Em = 3 lx (60%), minimal (absence) Em = 2 lx (40%), iii) 06:00 - off PL. normal Em = 3 lx (60%)

For calculation of the electricity consumption we took 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): i) western facade: Lm, w = 7.5 cd / m2, Em, w = 30 lx, ii) eastern facade: Lm, e = 5.0 cd / m2, Em, e = 20 lx, iii) southern facade: Lm, s = 3.0 cd / m2, Em, s = 10 lx, iv) northern façade: Lm, n = 3.0 cd / m2, Em, n = 10 lx

Given parameters are defined as the highest values for lighting in exceptional cases such as cultural or social events. Under normal operating conditions, the brightness values is lower. Three operating modes (regular mode, weekend mode, festive mode) are set for architectural lighting from the point of view of brightness and illumination.

For calculation of the electricity consumption, we take festive AL (Architectural Lighting) of 20 days during the year out of which 10 days will be weekdays and 10 days weekends.

Architectural lighting of the chapel is from the point of light color tone designed to allow for change of chromaticity temperature in a

minimal color temperature range from 3,000 K to 4,000 K. The chromaticity temperature is set according to the season and depending on the operating mode in a following manner:
a) Spring and summer: regular Tcp = 4,000 K, weekend and festive Tcp = 3 500
b) Autumn and winter: regular Tcp = 3,000 K, weekend and festive Tcp = 3 500 K

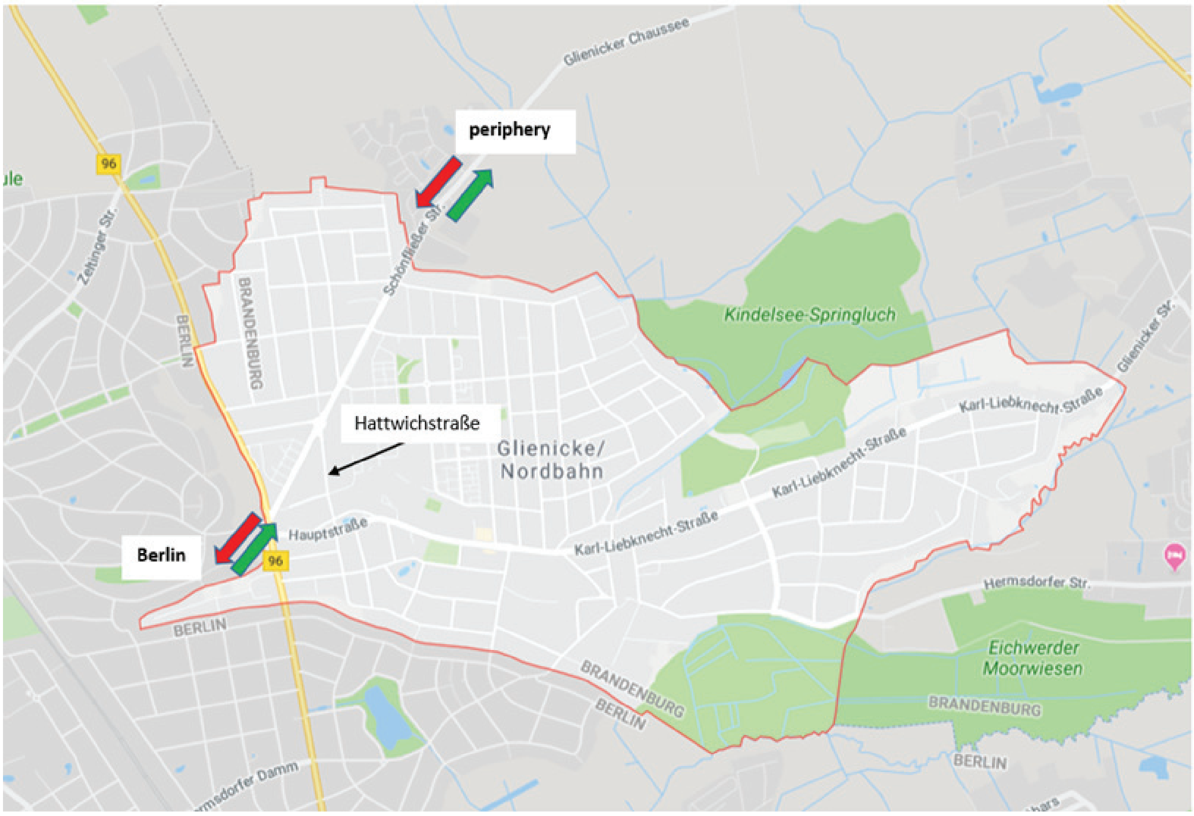
4. The Investment: Ownership and maintenance (durability), Investment costs, return of investment

The Town of Sušice is the owner of the street lighting infrastructure and responsible for the illumination of the municipality. The maintenance and operation of the system is ensured by the town company Sušické lesy a služby, s.r.o. who is responsible for the build-up and timeliness of the databases and other works, as well as the maintenance service for street lighting.
The total costs of investment was € 65 300 with calculated operation costs approx. € 295. From the overall perspective, the investment has extremely long return of investment. It is important to mention that within the investment the complete renewal of cables, lighting points (certification of luminaires included) and other lighting infrastructure were conducted.

5. Lessons Learned: Transnational effect and added value

The pilot investment in Town of Sušice is unique due to the combination of several aspects. One of the main aim was to proof the possibility of using dynamic control of public lighting in historical sites of the cities. Secondly, the project tests whether is possible to renew either old historical lighting points or luminaires (historical lantern) and install LED and dynamic control technologies in it. Finally, the part of the project was renewal of architectural lighting of historical building (chapel) using LED technology allowing changes in colour temperature.
The investment represents best practice example to other countries and points out main benefits but also obstacles in the whole process of realization the pilot investment.

3.4.1 GERMANY --- GLIENICKE/NORDBAHN



Geographic location of the pilot project in Glienicke/Nordbahn

1.Geographical location of the pilot project and the strategic value

Glienicke/Nordbahn is a city in Brandenburg, Germany, directly located at the border to Berlin, north of Germany's capital city. It is a city with strong growth, particularly since 1990, when after reunification people from Berlin started to relocate to Glienicke/Nordbahn. Between 1990 and 2015, the number of inhabitants grew by 176 % and has reached 12.155. Most buildings in the city are residential buildings with one or two floors. The next motorway is some 5 km away, and there are both national and county roads through Glienicke/Nordbahn. There is, however, no railway station.

Two different types of streets was chosen to implement the pilot dynamic lighting solution. Especially the Schönfließer Straße was selected, because this street is used by the transit traffic from Berlin to the periphery with an average traffic density with 9.000 vehicles per day. In comparison the second street of the pilot project, Hattwichstraße, is a residential street with about 4.000 vehicle per day. Also the traffic flows during the lighting times are very different in both streets. So that for the detection and designing of system answers at these streets various strategies was to solve.

2.Inventory lighting system and lighting situation

The inventory lighting systems was consisting of technical luminaires (type Philips SGS 203) mounted on curved “whip-type” poles (high 6 m) where Philips SGS 203 luminaires equipped with 50 W HPS lamps at the Schönfließer Straße and 70 W at the Hattwichstraße. Total electric power of the entire luminaire are 62 W and 83 W. Such luminaires are old (more than 20 years), require extensive maintenance and have low energy efficiency, especially compared to LED technology. HPS lamps create “yellow” light, with significant disadvantages compared to “white” light, which is even more so due to the transparent cover turning yellow over time, because of ageing. The existing lighting systems in the test area had no control systems dimming issues. The switching on and off of the luminaries was realised over components at the electrical power line.

The lighting measurements appear a deficient lighting level at both streets. It could be measured an average illuminance level on the lane of 4.7 lx at the Schönfließer Straße and 2.5 lx at the Hattwichstraße. Also the uniformity U0 was with values about 0,15 underneath of normative references.

3.Installed lighting system and new lighting situation

As new lighting systems LED luminaires (AREDO type from the manufacturer SWARCO) are installed. These luminaires were selected in a tender for the most recent modernisation project already, which means that the city has evaluated these luminaires in a transparent and independent process, including not only technical and price related, but also design criterions. The luminaires in the Schönfließer Straße have a total electrical power of 88,7 W and a total luminous flux of 10.500 lm. In the Hattwichstraße are luminaires used with a total electrical power of 44,8 W and a total luminous flux of 5.100 lm.

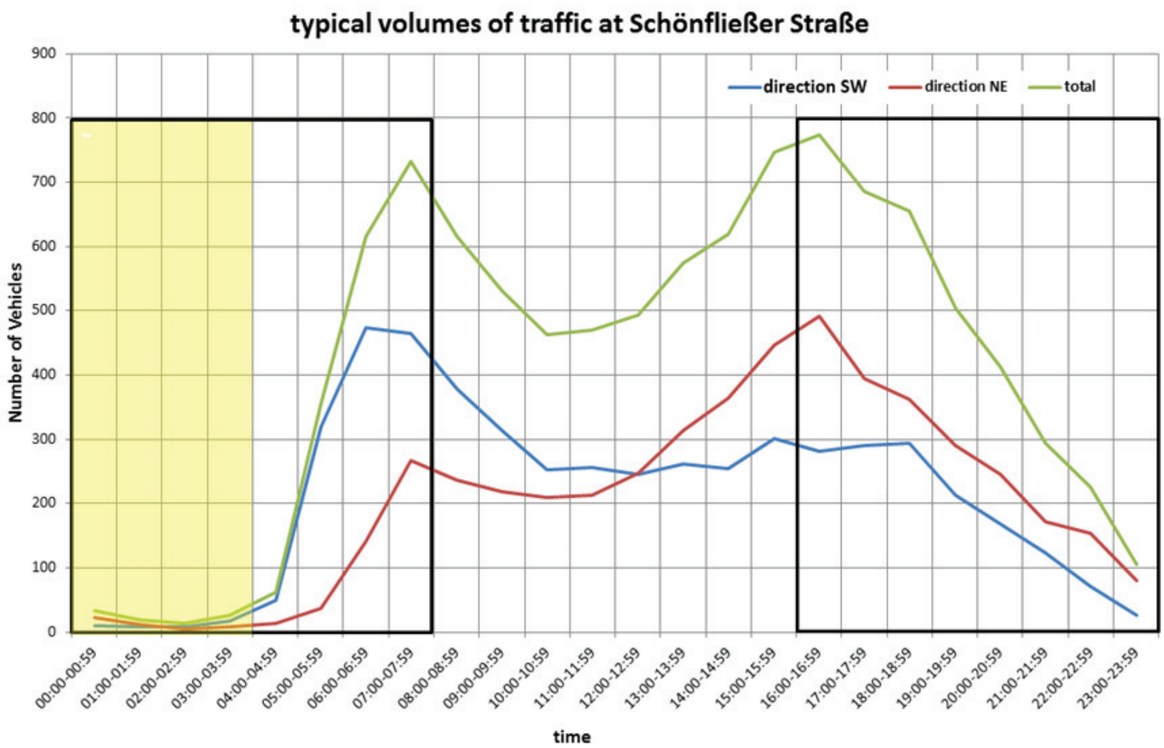
The new lighting situation in the Schönfließer Straße (up) and Hattwichstraße (down)

4.The dynamic light solution

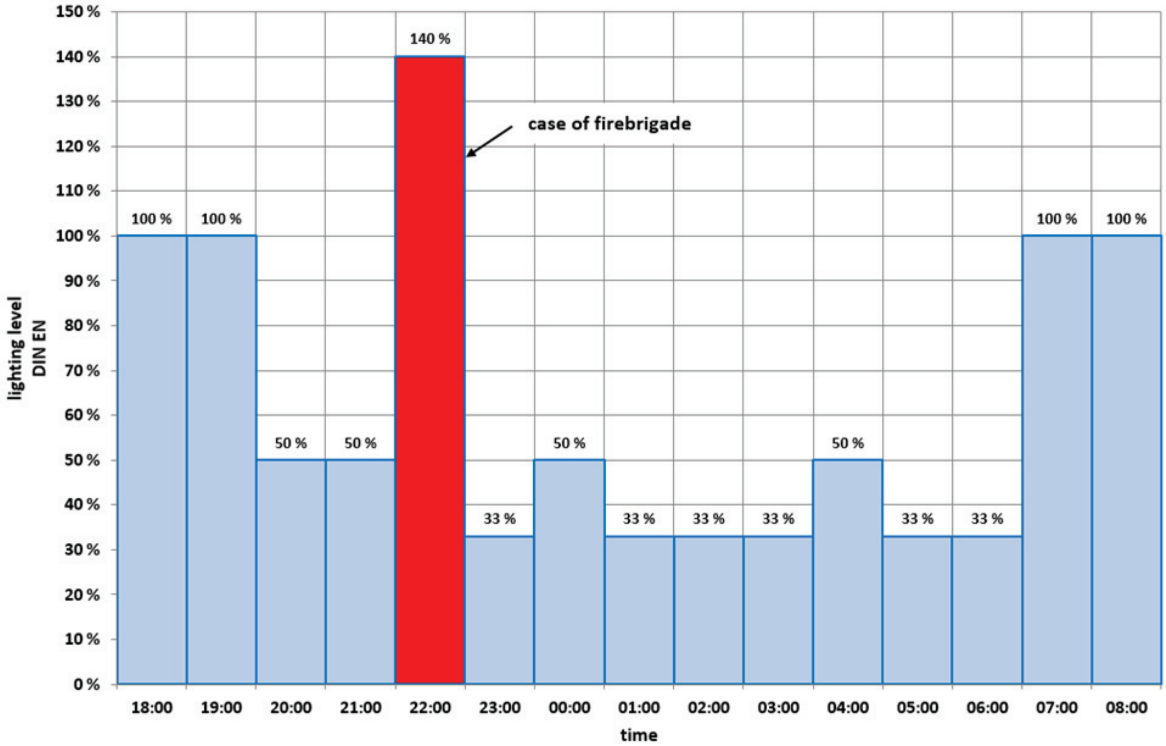
A dynamic lighting system is designed to give corresponding dynamic responses to external influence parameters such as number and type of traffic participants, time of day, weather conditions (e.g. wet road), environmental factors (e.g. CO2 emissions) or occurrence of dangerous situations. The technical basis of such systems are the sensors (detecting influencing parameters), the actuators (triggering of system responses) and a telemanagement system with corresponding data processing and defined procedures. In the present pilot project the control system is implemented via a telemanagement system (Volumlight, Schréder), which is part of the luminaires and allows bi-directional communication between the luminaires, sensors and the central control platform. There were two influencing parameters considered in particular.

1.Detection and control of the lighting system based on the number of vehicles:

For this purpose, the number of vehicles are detected by suitable cameras (Quercus SmartLoop TS) for both roads. The experiences clarified that when higher traffic volumes occur, a system response only on the basis of an integrative method (counting of vehicles at certain time intervals, e.g. 15 or 30 minutes) makes possible an acceptable dynamic answer. On the other hand, in residential streets with very low number of traffic participants at certain hours at night, system responses to individual vehicles can be a satisfactory solution. In addition, it is to examine which holding times are useful for the detection of individual or integrative traffic volumes for the respective road type.



Traffic density at Schönfließer Straße



system answers

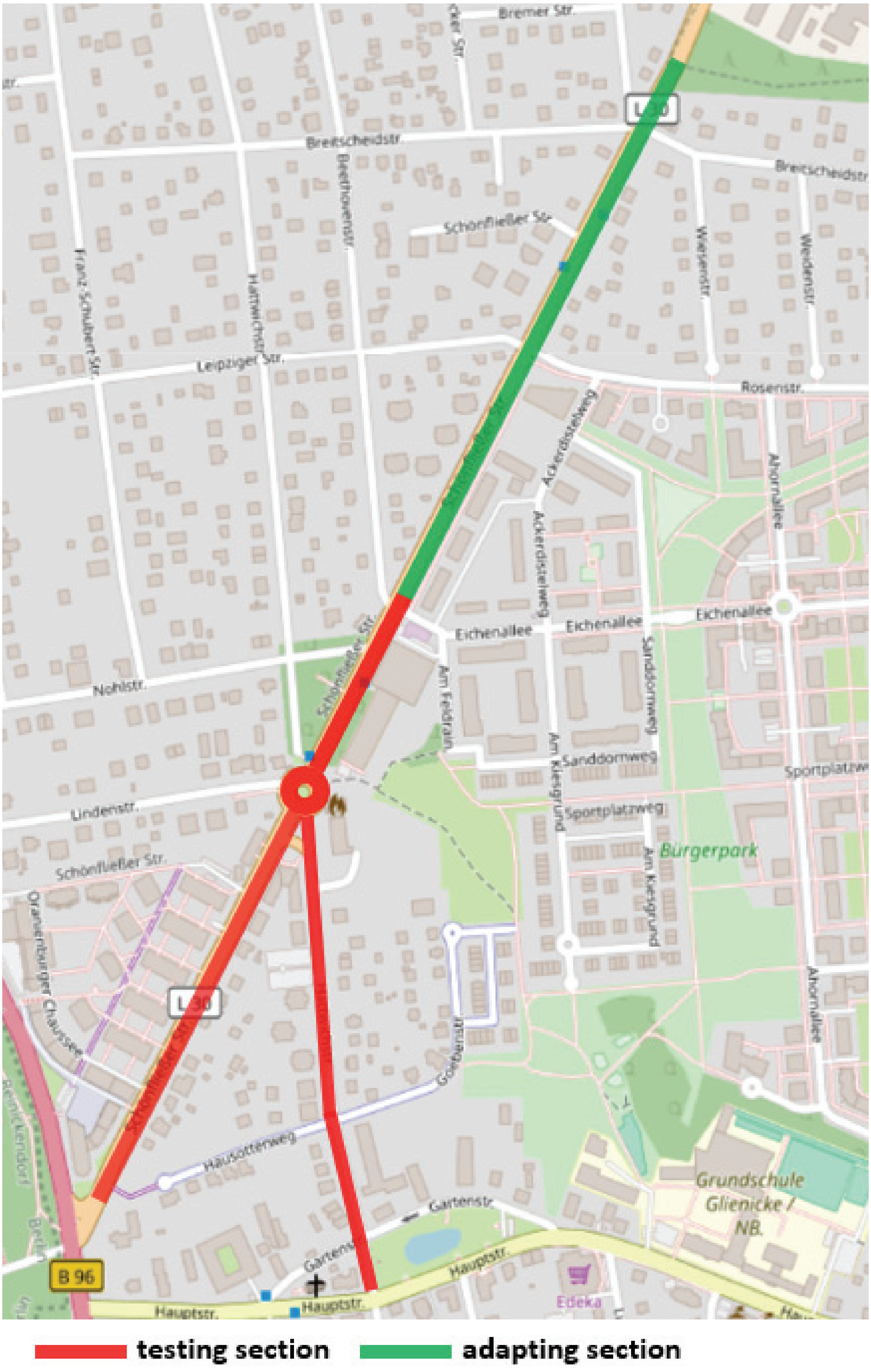
2.Detection of special situations and emergencies:

In the present project the operations of firebrigade vehicles and the time-limited increase of pupils around a high school are determined as specific situations, to which corresponding system responses was to generate. Both areas are located on Schönfließer Straße. At the fire brigade, the system response is provided by a signal generated parallel to the internal emergency signal and simultaneously transmit to the control system. At the Gymnasium, the detecting of pupil at the bus stops on both sides of the street in front of the school has proved suitable. Here the detection takes place by the cameras. In the case of emergencies (operations of fire brigade), the lighting level on both roads should then be increased to the maximum level (140%, see figure X).

5.System responses

In the example of Schönfließer Straße on the basis of the relevant parameters it could be determined that the following characteristics are present on the test track:

The total number of vehicles is 9,000 vehicles per day. There are more than 3 crossroads per 1000 m. The visual task in this section is given as "higher than normal" because of the presence of the roundabout, fire brigade and the high school. It can determined according to the DIN EN 13 201 part 2 a lighting class is given between M2 and M4. For this purpose, average luminance values between 0.75 cd / m² (50%) and 1.5 cd / m² (100%) are to be generated. In the night-time a luminance of 0.5 cd /m² (33%) is to generate due to the low number of vehicles.


Bremer Str.
Breitscheidstr.
Beethovenstr.
Schönfließer Str.
Franz-Schubert-Str.
Hattwichstr.
Leipziger Str.
Wiesenstr.
Weidenstr.
Rosenstr.
Ackerdistelweg
Ahornallee
Eichenallee
Nohlstr.
Am Feldrain
Sanddornweg
Am Kiesgrund
Sportplatzweg
Lindenstr.
Bürgerpark
Oranienburger Chaussee
L 30
Hausottenweg
Goethestr.
Gartenstr.
Grundschule Glienicke / NB.
B 96
Hauptstr.
Edeka
testing section
adapting section

6.Adaption section

During the project development, it became clear that the abrupt change of lighting level and light colour resulting from the partially brings visually and lighting specific difficulties. Therefore, the remaining section of this street was modernized with the same lights and realized an adaptation route. This adaptation route ends at the entrance to the town and also allows for a more homogeneous lighting along the bus line that runs here. Since there are no conflict zones on this section, the lighting level is regulated depending on the traffic figures between 0.75 cd / m2 and 0.5 cd / m^2 (M4, M5).

7.Ownership and durability

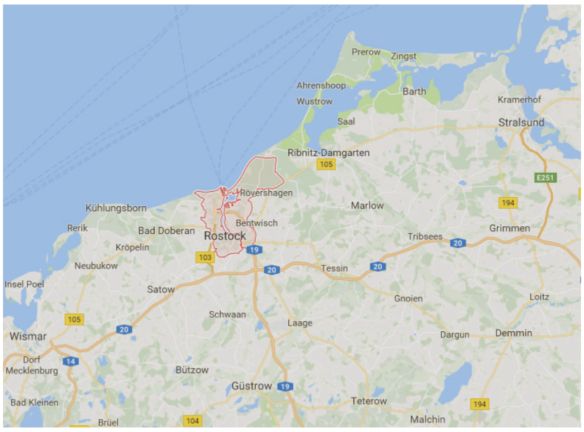
The lighting system realized here will become the property of the municipality of Glienicke / Nordbahn at the end of the year. At a Technical Committee of local council held in February, the implemented solution received a positive response. It was suggested that this project be transferred to other lighting systems in the community. Appropriate financial budget plans and community-based expertise are required to realise this in intermediate-term. As regards the continued operation of the telemanagement system and the associated dynamic lighting system, it has been shown that the municipality does not have the specialist staff. SWARCO V.S.M. is currently the operator of the lighting systems and, in the case of a community-side wish, can continue to operate these systems and also supervise the operation of the realized project after the end of the project period. In the case of a change of contractor for public lighting systems, either a corresponding clause must be included in the invitation to tender. In the worst case, the lighting system will continue to operate with a simplified control (fixed time dimming).

8.Lesson learned

For the realization of dynamic and smart lighting systems, the technical possibilities of the manufacturers have to be examined in advance. It is particularly important to ensure that the required components, which can often be found in the brochures of the manufacturers are not only prototypes and already proven series products. When purchasing components for dynamic lighting systems, compatibility has an important role if products from different manufacturers are to be combine.

The acceptance of the system owners (usually municipalities and cities) for dynamic lighting solutions can only be achieved with an intensive support of all participants (community leaders, citizens, institutions). In addition to today's prioritized energy savings, such discussions should also include the comparative presentation of lighting quality improvements. Consultation talks, presentations and participation in relevant community councils are helpful for this purpose. For the long-term use and dissemination of dynamic lighting solutions, technical assistance in cost and budget planning and tendering are indispensable.

3.4.2 GERMANY --- ROSTOCK



The Hanseatic and University City of Rostock is located in the north-east of Germany. With about 210.000 inhabitants, it is the most populous city of Mecklenburg- Western Pomerania and is considered as the economic and cultural urban center of the region. Rostock is characterized by its location by the sea, its harbor and the University.

Within the framework of the climate protection initiative of the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU), the Hanseatic and University City of Rostock has applied successfully for the "Action Plan 100 % Climate Protection" in 2011. It aims to reduce CO2-emissions by 95 % and energy consumption by 50 % until 2050 compared to 1990 levels. The improvement of the lighting infrastructure is one part pointed out to reach these objectives.

Street lighting causes 6 % of CO2-emissions and requires 1/3 of the energy consumption of the city administration. In order to use saving potentials and to make public lighting more efficient, the Hanseatic and University City of Rostock has developed a new lighting strategy.

The strategy for public lighting is geared to the long-term conversion to efficient LED technology and includes options for demand-based lighting control.

Through the implementation of pilot plants, experience has been gained how modern technologies can be used and the lighting can be designed like it is needed.

The pilot plants provide knowledge about the reliability and applicability of dynamic lighting systems and are basically for innovative lighting concepts for municipalities.

1.The site

The sustainable promotion of cycle traffic is of particular importance for the Hanseatic and University City of Rostock. Well-developed cycle paths, need an illumination which is harmonized to the use. For this reason, the 800 m long walking and cycling path along the road "Werftallee" was selected for the implementation of a dynamic pilot plant.

The path connects the two adjoining city districts and creates an important connection for the surrounding residential areas, the adjacent industrial area as well as for the tourism. In the first section the pedestrian and cycle path runs parallel to the road "Werftalle" and merges into a separate route in the second section. In this area, the path is surrounded by green area.

The protection of the environment, man and nature has priority and places special demands on the implementation of the dynamic lighting system.

2.The light

The lighting installation along the path was realized with 33 new technical LED luminaires (9 W) and is connected to the existing luminaires of the adjoining area. The luminaires have a control unit and integrated infrared sensors for motion detection. If the sensors detect a user, the intensity of the lighting is adjusted specifically for a specific road section.

The basic brightness of the luminaires is between 0 % and 10 %, depending on the environment. If a user is detected by a luminaire, the illuminance adjusts. If no user is in the detection range of the luminaires, the illuminance will be reduced to the basic brightness after a fixed time of 30 seconds.

In order to ensure a uniform illumination of the path, the luminaires transmit a signal to defined neighboring lights when a user is detected. The lights communicate with each other via radio.

A gateway has been installed for remote control of the system. The gateway summarizes the data of all connected luminaires and makes them available in a user-friendly web application. The connected systems can thus be easily monitored, controlled and modified by any computer with internet access.

3.The investment

The Hanseatic and University City of Rostock is owner of public street lighting. Therefore, the implementation of lighting installation is realized in responsibility of the city administration.

The lighting system enables a risk free use of the path in the dark hours and is part of the duty to ensure road safety.

The total cost of construction of the facility is € 151,432.46 (gross). These are composed as follows:

planning costs 14.775,05 €

procurement and installation

of the lighting system 110.457,64 €

sensors and lighting control

14.118,16 €

construction supervision

12.081,61 €

TOTAL 151.432,46 €

The funding was provided within the budget of the city administration of Rostock. The lighting control and sensors were funded by the European Regional Development Fund.

The relevant tasks in the organization of street and street lighting are fulfilled by the division of tasks of the city administration and the service provider for maintenance and repair of the lighting systems.

4.Lessons learned

The implementation of dynamic lighting solutions has shown the practical feasibility of the technology as well as the positive reaction of users on light on demand. The investigations and results of the pilot installation form the basis for the integration of dynamic lighting solution in general and especially in context of urban light concepts.

The investigations have shown that the demand based lighting control is well suited for use along pedestrian and cycle paths. Especially for these areas the decrease of light pollution is very important because these paths stretch many times through green areas.

Dynamic lighting helps to reduce polluting nature and environment and at the same time increases the quality of light.

The higher investment costs are offset by very high energy savings, which are significant over the lifetime. Compared to a constant illuminance during the dark hours, the use of a demand-based, sensor-controlled lighting can generate savings of up to 80 % depending on usage.

In future further demand-based lighting solutions will be used in the City of Rostock. In addition to the pilot's own knowledge the results of the other pilots will be considered. This is only offered by the exchange of partners throughout Europe

The participation in this project and the implementation of different pilots has shown the wide range of possibilities as well as the potential of lighting.

3.5.1 ITALY --- CESENA

Former Sugar Refinery in Cesena.

"CESENA(IT)-GREEN AREAS LIT ON A HUMAN SCALE."

1.The Site

Cesena is situated in northern Italy within Emilia-Romagna Region and has a population of about 96,935. The pilot investment has developed in the strategic framework of energy efficiency and sustainable development policies of Cesena in particular the new Sustainable Energy and Climate Action Plan (SECAP), the city initiative to reach the new EU 2030 CO2 reduction targets.

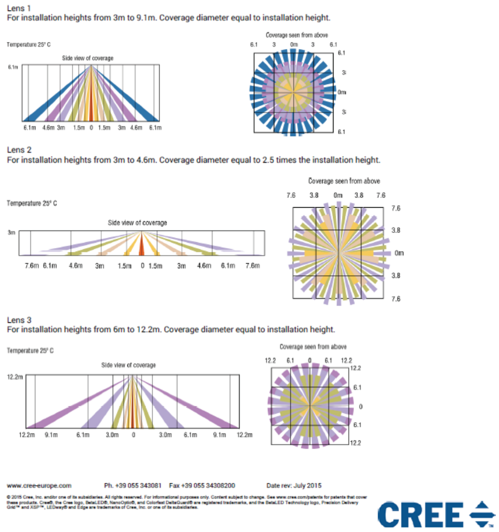
To test new dynamic lighting technologies the municipality of Cesena has identified as a pilot area a strategic portion of the city: the Former Sugar Refinery a big discarded industrial area (220.000 sqm) completely redeveloped in 2011 with a new residential headquarters (257 apartments), social housing and student flats, a shopping center (10.000 sqm), a business center (Bank of Cesena, offices.), pedestrian and cycle paths (10.000 sqm).

The Former Sugar Refinery is first of all a residential area with a high recreational potential of use with pedestrian spaces, cycle paths, green areas and has a strategic position within the urban context: located in the northwest it connects the historic old city center, with the Savio river and the large green area of hippodrome. Furthermore, the area has a high social value due to the present of the new University Campus inaugurated in 2018 and the presence of the resident's Committee

The 2 pilot areas:
11th September 2001 Park and C. Darwin Park.

Zuccherovivo set up in 2015 to revitalize the neighborhood with the municipality/institutions and families. These are the two main stakeholders identified and involved.

The social need analysis carried out in collaboration with the Committee with questionnaires, interviews mapping activities showed that the most critical areas for the public lighting are two park: 11th September 2001 Park nd the pedestrian path in the C. Darwin Park behind the new University Campus. The two green areas are strategic as passages within the neighborhood and before the intervention looked dark and abandoned, unsafe and not enjoyable.



Led street Lights CREE.

2.The Light

Starting from the site specific lighting social needs, the investment focused on a type of dynamic technology to: diminish the sense of insecurity; increase and diversify the attendance time in the two green areas (not only for passing but also for sports, games, recreational activities); increase the attractiveness for economic activities (bar and summer kiosks); create a comfortable and pleasant atmosphere avoiding the light pollution. The investment provided the following technical interventions within the 2 public parks:

"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 with passive infrared sensing technology (PIR) that can detect the presence of pedestrians at three different distances (6m, 7 m, 12 m). Currently the sensor is set over a distance of 7 meters. 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, provide a flexible tool to adjust the light to the social activity around each light point and to experiment and validate different dimming profiles.

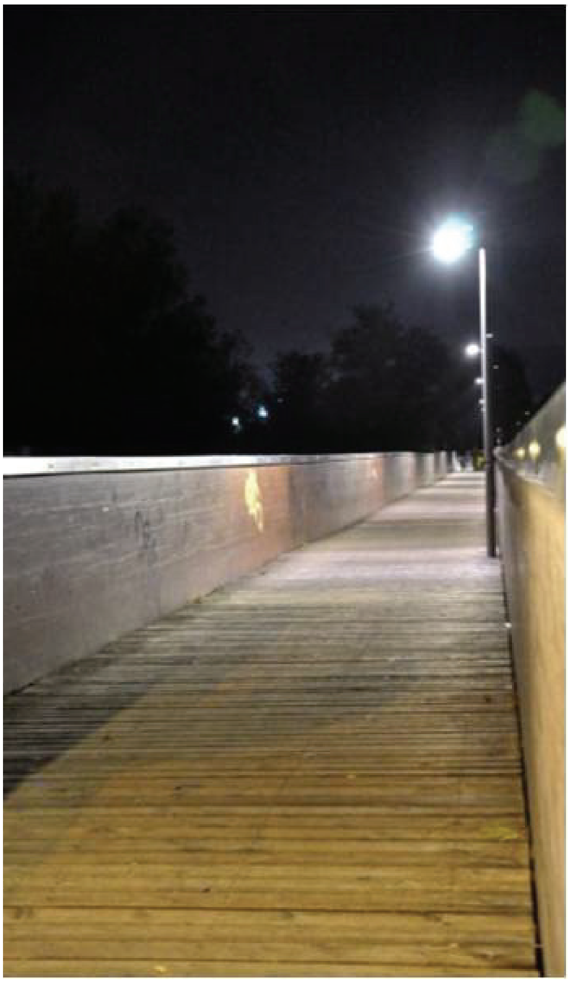
The investment will allow to reduce the electrical consumption of the plant by 77% also contributing to the reduction of CO_2 emissions. This result contributes to the environmental objectives defined within the sustainability plans approved by the Municipality of Cesena and in particular the SEAP and SECAP.

The pilot plants during the official inauguration on 22th October 2018.

3.The Investment

The investment within the two public parks amounts to € 67.995,01.
The municipality of Cesena owns the whole area of Former Sugar Refinery and its lighting infrastructures.
Regarding the maintenance and durability of the investment, the Public Building Sector of the Municipality of Cesena will be responsible for the control and monitoring the new plants in close collaboration with Hera Luce Ltd, the

company that managed the urban lighting network through an agreement signed in 2015. Within the agreement, the Municipality of Cesena has main function of directing Hera Luce's investment policies and setting new objectives and quality standards to innovate the lighting network through specific "Investment Plan".



4. Lessons Learned

The investment implementation has allowed the acquisition of new technical know-how for the co-design of dynamic lighting systems that for the first time includes an effective social approach taking into account the specific lighting social needs of citizens, who become not only the final users but also intervene in the preliminary design phase.

The investment has therefore enabled a new way of working on public lighting systems experimenting a real model of smart cities in which the municipality, citizens and technicians work together to improve the liveability of urban spaces starting from the light.

Moreover the investment is a good practice that can be easily replicated in pedestrian and green areas. The Municipality of Cesena leading the Union of the municipalities of the Savio Valley, which includes 5 other small municipalities. In the future this good practice will therefore potentially be replicated in other cities of larger territory.

Participatory co-design process with the Committee Zuccherovivo.

3.5.2 ITALY --- MANTOVA

Municipality of Mantova

"PP06 TEA S.P.A. (MANTOVA, IT) IMPROVING PUBLIC LIGHTING IN A GREEN AREA."

1.The Site

The city of Mantova is located in the Southeastern part of Lombardy Region, in the heart of Pianura Padana. It is surrounded by three artificial lakes and most of the neighboring territory is included in the nature protection area called Parco Regionale del Mincio. The typical main resources are agricolture, livestock farming and all tourism activities: Mantova is an old Renaissance town, UNESCO World Heritage Site since 2008 and Italian Culture Capital in 2016.
Bosco Virgiliano is an "Aggregative Area" of landscape and monumental value that stretches away for about five hectares and locates itself in the southeastern part of the historic city, with the main access from Via Parma.
The main cycle and pedestrian ring path (about 1,3 km, included in EuroVelo Circuit) within it has been selected as the pilot area to be hosting the first European "Bio-Dynamic" lighting experimental implant.

The area occupied by Bosco Virgiliano has been categorized as "Ambito a Sensibilità Paesaggistica Alta - High Landscape Sensitivity Environment" and falls within the Parco del Mincio perimeter.
The park conformation and its location in relation to the city center make it used especially by residents of peripheral quarters,

but it also attracts distant citizens and tourists as city green lung.

It hosts protected facilities as the SOS Village, a cooperative offering welfare services to minors, the municipal dog and cat pound "The Refuge" and "Parcobaleno" wild fauna rehabilitation center, whose activities involve several volunteers. In the neighboring zone there are the "Tazio Nuvolari" School Camp, a horse stable, a motocross track, the Rugby Mantova sport field, the Tennis Club and the National Target Shooting Range, all attended by athletes and amateurs.

Despite all this, Bosco Virgiliano presented an irregular and not functional illumination and a complete lack of any video surveillance system. According to surveys on stakeholders and frequent users, this location turned out to be one with the greatest social and environmental issues in the whole city.

2.The Light

The project aims at giving a concrete answer to a deeply felt community issue: green areas usability in safety. In particular, main purposes are to protect the users, guaranteeing their safety and making a currently rarely frequented area, inasmuch not adequately illuminated, available to be used again, together with monitoring it in order to discourage elements of social disturbance from stopping over. The complete lighting system redevelopment of the old implant has also assured energy-savings, remarkable light pollution reduction, CO_2 emissions decrease and a high operational cost-effectiveness, as well as the introduction of innovative "Smart City" services which add value to the historic-artistic interest of Bosco Virgiliano.

The old lighting system, pretty obsolete and energy-demanding, has been completely revamped. Light points have been improved in quality, increased in number and relocated, with the adoption of high efficiency "Full Cut-Off" standard LED light centers for park's opposite ends (the main monumental entrance and a statue roundabout) to obtain a practically total reduction of light pollution. As ring path's Light Points, such "Full Cut-Off" LED light centers are "Bio-Dynamic", meaning they are able to both change the quantity of emitted light and change its color temperature between 2.700 K (yellow)

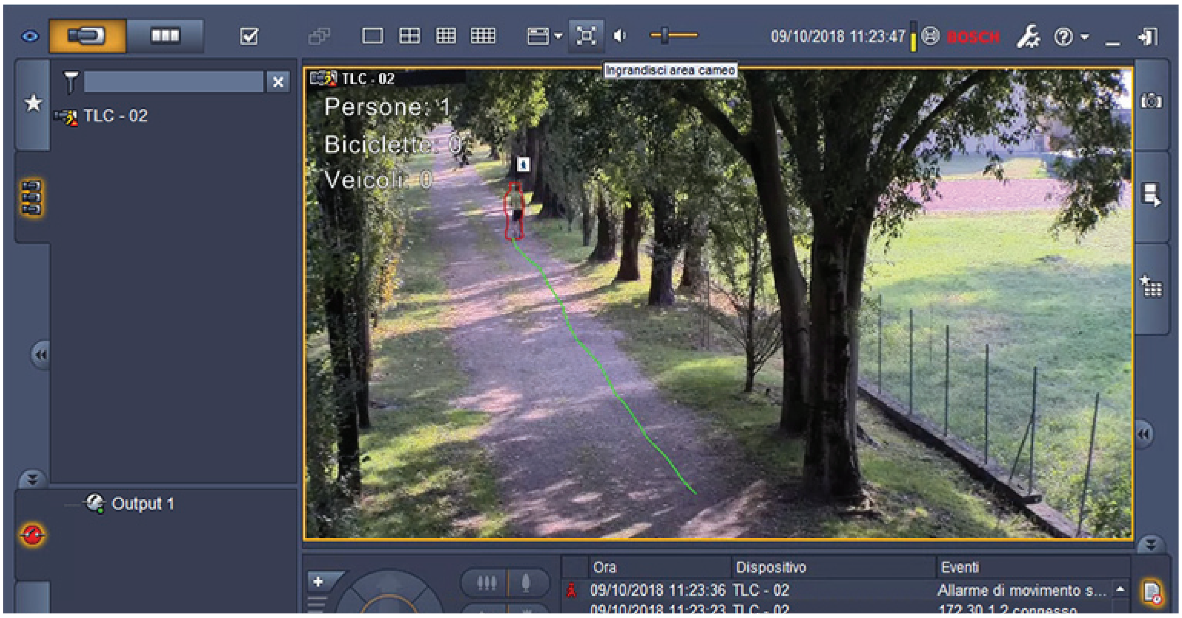
Bosco Virgiliano's ring path and some neighboring facilities and 4.000 K (white). This "Bio-Dynamic" effect is achieved thanks to the implementation of an innovative system: detection of users in the area through a brand new optical fiber infrastructure and video cameras with onboard "Intelligent Video Analysis". By means of machine learning patterns, this software creates different profiles based on the type of users (pedestrians, bicycles…) and/or specific conditions (fog, emergencies…), through a power-line network transmits the coded information to light centers, which supply the related customized and correct light amount to the interested sectors (six Light Groups of ten light sources each, every Light Group is covered by about 2 Video Cameras). Contextually, the pilot area can also be constantly video monitored.

In completion of park technological redevelopment, two single-face and touchscreen multimedia totem have been installed at the two opposite main entrances, in order to describe park's history, the project and to collect feedbacks thanks to dedicated surveys.
Since the pilot area is located in a context subject to environmental protection regulations, specific attention has been paid to new infrastructures mitigation. All implant's poles (and both totem as well) have been installed on a new type of concrete-free hot dip galvanized

	LIGHT BODIES				IMPLANT				
	Light Center	**Emitted Power [W]**	**Luminous Flux [lm]**	**Luminous Efficiency [lm/W]**	**Light Centers Amount**	**"Smart" Systems**	**Average Illuminance [lux]**	**Illuminance Uniformity (min/med)**	**Total Power [kW]**
BEFORE	HPS (High Pressure Sodium) Globes	100	8100	81	56 (on 28 poles)	-	1,47	0,10	7,00
AFTER	"Full Cut-Off" & "Bio-Dynamic" (2700K-4000K) LED (Light-Emitting Diode)	30-54	3600-12600	118-144	60 "Full Cut-Off" & "Bio-Dynamic" + 14 "Full Cut-Off" LED (on 74 poles)	15 «Intelligent Video Analysis» Video Cameras + 2 Multimedia Totem	5,00 (2700K) 15,00 (4000K)	0,41 (2700K) 0,41 (4000K)	2,60

Before/After Implant's Technical Details

Light Centers



"Intelligent Video Analysis"

steel "screw" foundations with the lowest environmental impact possible. This mechanical support system of the pole 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. Furthermore, poles, light bodies and video cameras have been properly painted with a color (RAL 7022) suitable for the best integration in the environmental context.

3.The Investment

The overall investment for the whole redevelopment amounts to € 202.880,74.
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, followed by lighting and electrical executive design, complete with specialist

"Screw" Foundations & Multimedia Totem.

technical report, report of photometric survey about current situation, design lighting simulations, electrical systems calculations and data sheets regarding identified components. Then, 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, accompanied by photographic evidences, planimetries and reports.

The installation of implant components and all accessory structural works have been performed by TEA Group, the Multiutility of Mantova Province's territory, through its subsidiaries: TEA Reteluce S.r.l. as regards electrical and lighting field and Mantova Ambiente S.r.l., specifically its Green Spaces Service, as regards structural field and forest heritage protection.

October 2018 Study Visit - Tea Group Headquarters (Mantova, Italy).

4.Lessons Learned

Municipality of Mantova is going to benefit by this cutting-edge technology within its territory, through important energy and costs savings, making a step forward in fight against light pollution and CO2 emissions reduction. All users and public security will also benefit from new Bosco Virgiliano pilot plant thanks to more performing lighting and dedicated videosurveillance. Since Bosco Virgiliano is located in a protected environmental context, the pilot area might hopefully become a scientific educational center about environment and sustainability, as well as being destined for hosting exhibitions and events, also easily reachable by public transports. Taking advantage of the new technological grid, it will be possible to integrate electric mobility

October 2018 Study Visit Bosco Virgiliano (Mantova, Italy)

stations for cars and e-bikes and prearrange smart parking lots available to people with legally protected statuses, in order to make city more pleasant and liveable and improving citizens life quality.

TEA Group will exploit such pilot area as experimental site for new technological implementations, taking advantage of it in order to test sensors dedicated to analyze and monitor parameters about weather conditions, environmental status, phytobiology and a wide range of other fields.

Good practices and learning through cooperation are effective mechanisms for spreading know-how and enhancing competitiveness. Transnational learning implies that actors learn to work at new scales and in new types of networks, in order to better address certain issues of transnational importance or better address specific local or regional issues by learning from other actors. Projects studies have shown that various types of knowledge transfer can be performed, including methods and good practice, models and data, expertise and measures, ideas and visions. Exchange of knowledge and experience about common problems is definitely an added value able to encourage local and regional actors to “think outside the box” and mobilize political engagement to face old and new challenges.

February 2019 Local Training Seminar (Mantova, Italy)

3.6 SLOVENIA --- GORENJSKA

1.The Site

Gorenjska region is alpine region situated in northwest of Slovenia with capital city of the region Kranj with 40.000 inhabitants. Gorenjska consist of 18 municipalities and 3 of them are our pilot municipalities with different type of areas. The investment is carried out on the territory of 3 local communities Bled, Jezersko and Tržič in region Gorenjska. Diversity of areas (touristic area- Bled, mountain settlement/protected area in Jezersko and urban industrial area in Tržič) contributes to capacity building and acceptance of dynamic lighting by stakeholders and users. It contributes also to lowering of costs of local communities for lighting (electricity costs) and reduction of the lighting pollution. At the same time pilot investments show the way to further improvement of public lightning in other areas in 18 local communities in Gorenjska region and contribute to the positive image of dynamic lighting.

The pilot investments corresponds with strategic framework of sustainable development policies of Gorenjska in particular the new Sustainable Energy and Climate Action Plan (SECAP), with a total reduction of CO2 emissions by 40% in the Gorenjska region by 2030 compared to the base year 2005.

We identified 4 pilot areas in 3 different municipalities. In municipality Bled we implemented two separate pilot areas, 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.

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

Figure 1: park Vile Zora (Bled)

Figure 2: park Vila Bled

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.

Figure 3: Industrial zone Mlaka (Tržič)

Figure 4: Road near lake "Planšarsko jezero" (Jezersko)

2.The Light

In preparation of pilot project we considered specific social needs, type of area, project focus and follow national legislative, norms about public lighting standards and also took into account requirements of the Institute for the Protection of Cultural Heritage of Slovenia where it was requested (Jezersko).

2.1 Pilot Bled

1A. Park Vile Zora

- Supply and installation of 16 luminaires with sensors&controllers. 1 luminaire is financed within the scope of the project whereas 15 luminaires are financed by the municipality of Bled. These are road lighting lamp with basic technical characteristics - LED Type, maximum lamp width 19W, life time 50,000h, colour temperature 3.000K, Ra> 70, min. Flow rate 1.800 lm. (Luminaire, Bega 99 401, Bega); installation of 4m high pules (16 pieces).
Lighting regulated according to user density - light control from 50% to 100% - from 24h to 5h, lighting is switched off.

1B. Park Vile Bled

- Supply and installation of 6 luminaires - Road lighting lamp with basic technical characteristics – LED Type, maximum lamp width 19W, life time 50,000h, colour temperature 3.000K, Ra> 70, min. Flow rate 1.800 lm. (Luminaire, Bega 99 401, Bega); installation of 4m high poles (6 pieces). Lighting regulated according to user density - light control from 50% to 100% - from 24h to 5h, lighting is switched off.
- Supply and installation of 42 luminaires on existing poles, which with specific shape under cultural protection. 36 luminaire is financed within the scope of the project whereas 6 luminaires are financed by the municipality of Bled. These are footway lighting lamps built into urban furniture (concrete pillar) with basic technical characteristics - LED Type, maximum lamp width 13W, life time 50,000h, colour

Figure 5: new luminaires with sensors&controllers (Park Vila Zora)

temperature 3.000K, Ra> 70, min. Flow rate 1.800 lm. (Luminaire, Geolux Sphere). The dimensions and method of assembly of lamps on the concrete pillars is determined by the existing lamps and urban furniture (concrete pillars) of Vila Bled and surrounding park.

2.2 Pilot Jezersko

- Supply and installation of 13 luminaires - Road lighting lamp with basic technical characteristics - LED Type, maximum lamp width 18W, life time 50,000h, colour temperature 4.000K, Ra> 70, min. Flow rate 2.500 lm. (Luminaire, LSL, Grah Lighting); installation of 6m high poles (13 pieces). Lighting regulated according to user density - light control from 50% to 100% - from 23h to 6h, lighting is switched off.
- Supply and installation of 7 luminaires - Road lighting lamp with basic technical characteristics - LED Type, maximum lamp width 112W, life time 50,000h, colour temperature 3.000K, Ra> 70, min. Flow rate 13.000 lm. (Luminaire, Lightstream LED maxi - 721734.1131.76, RZB); lamps will be only used for the purpose of cross-country skiing which area leads beside the road. Lighting for cross-country skiing will be mounted only on locations where recreational path will be active - based on the snow conditions.

In areas where only the road surface is illuminated 6m poles are used, while on the parts when the road surface illuminates and the “recreational path” combined poles are used with a total height of 8m (6m + 2m-mounting extension) on which the lamps are mounted on two different levels (6m and 8m).

2.3 Pilot Tržič

- Supply and installation of 14 luminaire - Road lighting lamp with basic technical characteristics - LED Type, maximum lamp width 68W, life time 60,000h, colour temperature 4,000K, Ra> 70, min. Flow rate 9.300 lm. (Luminaire, STREET G (XP-L V4) Luxtella); Supply of 14 galvanized poles/candelabra with a height 9.8 m above the floor.

Figure 6: new luminaires on existing poles (Park Vila Bled)

3.The Investment

The financial volume of all 4 pilot investments amounted to 219.069 € with included VAT, 169.069 € of which was contributed by the municipalities themselves, the rest was co-financed within project Dynamic Light.
According to the Slovenian law the owner of public lighting are municipalities, which has obligation to maintain public lighting infrastructure. Included municipalities (Bled, Jezersko, Tržič) are owner of public lighting system in the pilot area and therefore they are paying costs for energy consumption. For maintenance of lighting infrastructure conducts subcontracted private company. Every of included municipality has their own subcontractor.

Figure 7: new luminaires on combined poles in Jezersko

4.Lessons Learned

Implemented pilots in three different municipalities with different types of area from tourist, mountains, parks and industrial areas. Realization of pilot investments contributed to capacity building and acceptance of dynamic lighting by stakeholders and users in the region.

MUNICIPALITY	Nuber of luminareres in proposal	Total power comsuption [W]	Annual operation [h]	Electricity consumption [kWh]	SAVINGS - Power regulation with regulation of luminous flux based on traffic intensity and operation time [%]	SAVINGS/ YEAR - Electricity consumption [kWh]	SAVINGS/ YEAR - Electricity consumption [€]
TRŽIČ	13	103	3.800	5.088	45%	2.799	263,31
BLED (PARK VILA ZORA)	16	19	3.800	1.155	45%	635	59,78
BLED (PARK VILA BLED)	6	19	3.800	433	45%	238	22,42
	42	10	3.800	1.596	45%	878	82,59
JEZERSKO	15	76	3.800	4.332	45%	2.383	224,18

It demanded lot of engagement from all involved staff through preparatory phase, creation of final project and procurement documentation and finally implementation of investments. Exchanging of know-how during the project with pointing out main benefits and obstacles, was added value and contributed to the final pilot solutions. At the same time pilot investments show the way to further improvement of public lightning in other areas in 18 local communities in Gorenjska region and contribute to the positive image of dynamic lighting.

CHAPTER 4
CONCLUSIONS

In the face of ever more pressing environmental, economic and social challenges and the desire for sustainable development, the question is whether and how light could once again become an important driver of environmental, economic and social innovation. What can light do as an innovation driver?

The Dynamic Light project consisted of a trans-European consortium of 17 partners from various backgrounds like education, municipalities, energy agencies, city councils to name a few. Under the direction of the lead partner- University of Wismar - this transdisciplinary exchange between partners of different disciplines, scientists and experts from various countries led to trend-setting ideas and concepts that help to redefine the role of light in future public space.

The results of the dynamic light research project are many folds. The project has developed 8 Pilot actions to showcase the practical application of dynamic light in public spaces. In addition, a number of tools and manuals have been developed to help and guide the urban planners, designers, civic authorities, municipalities and energy providers to implement dynamic light in public spaces. The manuals will help in establishing user needs and demands, provide guidelines for urban planners on lighting masterplans. Further, Handbooks and practical toolkits are envisaged to help the planning authorities to plan and implement dynamic public light appropriately.

The "dynamic light" creates a social consensus about the expected behaviour in a group and insinuates the corresponding patterns of behaviour. Whereas in the past spaces and their materials were analogous objects that created order and postulated behaviour, in the future it will be possible to design digitally controlled elements by means of designed light, and much more precisely to support different types of behaviour virtually to the minute.

This Dynamic light project is an important step in creating awareness about the changing public spaces and technology, helping to develop this idea by discussing the new technical and design possibilities.

4.1 OUTPUT

The varies outputs- manual, guidelines, tool-kits, handbooks provide a set of tools for designers, technicians, urban planners, civic authorities, municipalities from any region or territory, enabling them to develop dynamic lighting strategies for their particular region or territory or type of location. These provide a wide range of tools that are valid and easily modified for individual regions and territories. In the process, creating a set tools to discuss concepts like human needs, light pollution, adverse effects to Flora & Fauna alongside issues like light quality, energy and cost savings. To generalise the main outputs have been:

- Promoting user-accepted energy efficient lighting solutions by improving the quality of light according to social needs.
- Harmonized public lighting standards and norms
- Capacity building to improve the energy efficiency in public lighting infrastructure and positive image-building for the application of dynamic lighting and energy-saving

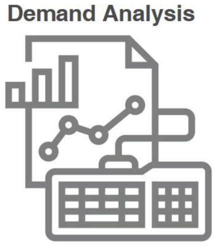
Work-Package 1

These manuals and tools provide Urban planners, architects, lighting designers etc. with a guide/ tool for understanding social needs, user demands and aspirations, and how these can be translated into dynamic lighting control strategies. Through the use of practical tools developed in the previous deliverables, like- Monitoring Tools and Demand Analysis, information about the needs and demands can be collected on location. Monitoring tool enables detailed information gathering and the demand analysis assists in organising and prioritising the information collected in the first stage.

The manual on transferable technical solutions along with the manual on dynamic lighting and social needs completes a set of manuals aimed at outlining the factors which are essential for light quality, ecology, energy efficiency and subsequently social sustainability. The objective of this manual is to provide Urban planners, municipalities, authorities, technical consultants with a tool for understanding social

Joint Monitoring Tool

Demand Analysis



Manual Social needs

Manual Technical solutions

Dynamic Lighting Design Strategy

needs, user demands and aspirations, and how these can be translated into dynamic lighting control strategies using the upcoming technology.

These manuals will help the partners in developing lighting strategies to meet the varied needs and demand of their respective regions and territories. The local public authorities will be able to establish the direct connections between satisfying the user demands and social needs and the technology available for this purpose. Through these manuals the ideas of light quality can be directly linked with the technical solutions.

Work Package-2

Amongst the various outputs the main ones can be summarized as follows:

- Development of GIS-based databases for municipalities with focus on energy-efficient city lighting. These databases can be used as models for other municipalities to allow for the strategic planning of dynamic lighting solutions.
- Development of a guideline on finding the suitable financial model for public lighting investments based on the evaluation and adoption of best practice examples of financial models for investments of the public sector in energy-efficient public lighting.
- Transnational multiplier trainings as well as trainings on local and regional level in each partner country using purpose made transferable curricula and training materials
- Development of joint course curricula and training material for the lighting sector of municipalities and education of urban planners and light designers.

Work Pacakge-3

The main outputs of this work package have been the 8 Pilot actions and subsequent Best practice and evaluation guide.

By following the best practice 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.

Work Pacakge-4

The main outputs for this work package are as follows:

- Development of a strategy to include dynamic lighting in the norm EN 13201 stating in which parts EN 13201 needs to be updated in terms of dynamic lighting.
- Development of a handbook as a tool to address Standards Committees to adapt strategy draft and consider it in the next step.
- Development of a strategy to facilitate the integration of dynamic lighting from a legal perspective under consideration of the legal and political framework to promote standardised quality for public lighting in accordance with social needs and user demands.

4.2 CHALLENGES

The UN forecasts that today's urban population of 3.2 billion will rise to nearly 5 billion by 2030, when three out of five people will live in cities. Urban landscapes are expanding and growing at an astounding pace to accommodate our ever increasing population, needs and demands. In order to have places that are lively, safe, sustainable and healthy, the ideas of social sustainability along with an open and democratic society needs to be developed and strengthened. One major step towards this is to focus on the human factor, reinforcing the social functions of a space. The need and demand for better urban quality can be directly related to the improvements for people in an urban space. Creating cities, towns and communities that are economically, environmentally and socially sustainable, and which meet the challenges of population growth, migration and climate change will be one of the biggest tasks of this century. The urban realm today is confronted with challenges never witnessed before, coping with overcrowding, pressure on housing and transport systems, climate change and ageing societies, changing behavioural patterns bought on by new technology and media; added to this the impending energy crisis and environmental disasters.

Through urban planning and design, architecture, public policy research, housing management, community development and local government participation, using different languages, professional approaches and ideas we are constantly trying to evolve solutions that can overcome all these challenges.

Unfortunately, many municipalities, towns and cities are far from adapting or implementing energy efficient directives and solutions. The main barriers for acceptance are scepticism, lack of knowledge, outdated government policies, procurement rules, and higher capital cost of new technologies with long payback periods.

Also, a very critical factor in the lack of implementation of sustainable practices is the fact that with the introduction of new energy efficient technologies, more sophisticated methods of planning and design are necessary to make use of the possibilities to reduce the energy consumption of public lighting. These new possibilities in planning and design have to be understood before lighting installations can be updated with the aim of reducing energy.

It is paramount to guide, raise awareness and build technological and technical capacity between the various groups involved in urban lighting schemes. This will foster a better understanding of energy-efficient lighting technology and the way how to use it, eventually giving authorities the confidence and encouragement to implement such technologies.

4.3 FUTURE PERSPECTIVE

Evolving urban spaces: Urban spaces are increasingly experienced as a relative rather than an absolute value. Further there is a trend towards the shrinking sense of Public spaces. The city is evolving into increasingly private clusters of loosely connected “islands” or zones. Added to these changes shopping blocks, entertainment centres, business parks are also changing the scale of the city. These developments are giving rise to the need for flexible and adaptive systems of lighting. Lighting systems that need to respond to the new and unique demands created by such urban changes. Need for light is becoming more individualistic, not bound by time or space.

Such changes in the need for lighting, will eventually lead to re-thinking in the approach of public lighting. Public lighting need not be bound by a specific time or to a specific place. Good quality light cannot be restricted anymore to important city centres.

Evolving urban Lifestyles: The technological revolution has brought about a quantum shift in our lifestyles- being constantly connected to the entire world through the electronic devices. This has resulted in a shrinking world, where physical distances are no longer significant. Technology has broken the traditional boundaries of time, distance and space. The very purpose for public lighting is being transformed because of these changes, the need for functional lighting to get from point A to point B, will be replaced by the need to have right quality of light for social interaction, entertainment, exchange and awareness.

Social media platforms along with the omnipresent smartphones are providing innovative methods for designers and urban planners to better understand a city, its functions and the user’s behaviour. Many social media platforms allow posting and uploading of status, location and most importantly photographs. Such information which is freely and openly available on the internet can be used as a powerful tool for urban design analysis, tourist and public movement, time and duration of stay, complaints and problems to name a few.

Internet of Things and Big Data: The concept of IoT is simple, everyday objects will have network connectivity, allowing them to send and receive data across a network, whether that’s wired or wireless. Sensors can detect motion, direction, footfall, ambient light levels, temperature, light output, colour temperature, quality and operating temperatures. On-board processors can locally analyse the data they receive or upload it to the central management system.

Self-learning and correcting systems: Through Dynamic lighting controls, an intelligent self-learning system can be envisaged, that can learn by itself and implement changes and modifications as required. The vast array of sensors, control systems and data processing applications offer the singular opportunity to study and learn from various parameters, variables and conditions. Such solutions can analyse the various parameters and variables affecting public lighting in a situation and through possibilities offered by Big-Data and data processing can easily learn and predict the lighting requirements in the future.SMART **Indicators for a “Smart City”:** The traditional SMART indicators are defined as:

- specific,
- measurable,
- achievable,
- relevant and
- time-bounded

The SMART indicators are a tool that allows each set of stakeholders to measure progress in their own sector as well as indicators that function as checks and balances on the progress of other sectors. These set of indicators can easily be adapted to public lighting, allowing for the assessment of the broad and inclusive vision of a desired future for a place, but also to include the detailed measures of success that indicate positive progress towards that vision.

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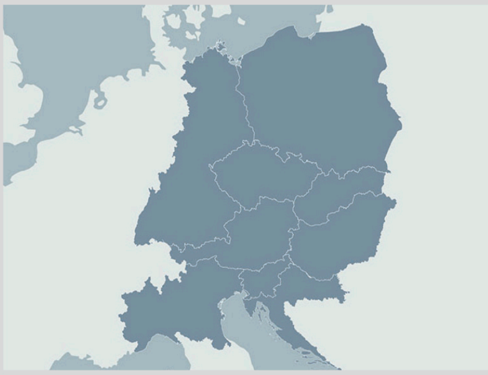

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