ENIGMA

State-of-the-Art in Urban Public Lighting

Research results WP1.1 - 31 March 2014

dr.ir. Elke den Ouden & dr.ir. Rianne Valkenburg
Intelligent Lighting Institute, Eindhoven University of Technology, the Netherlands

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Introduction

The ENIGMA project

Introduction

Led by Eindhoven, ENIGMA aims to implement a joint transnational pre-commercial procurement (PCP)procedure in the field of lighting.

The project's partner cities Eindhoven, Malmö, Stavanger, Espoo and Bassano del Grappa, will define a common public lighting challenge and launch a European call for solutions. After initial research and idea screenings, possible solutions will be piloted in real life environments within each partner city.

Over the course of three years, this piloting process will be accompanied by knowledge exchanges and learning through visits between the participating municipalities and through in situ and online courses in PCP development and management.

While lighting will be ENIGMA's main theme, related issues such as energy efficiency, safety and cultural heritage will also be taken into consideration according to the specific requirements of each pilot site.

Partner cities

In the ENIGMA project the five partners cities will jointly procure a smart lighting solution and implement it in a pilot area.

Eindhoven
With a population of 220,000 inhabitants, the city of Eindhoven is the 5th largest municipality in The Netherlands. As a knowledge based and innovation oriented city, Eindhoven focuses on creating the needed support structures in the domains of innovation, labour market, technology development and business development. The municipality has a political ambition to become a Living Lab for innovative technology solutions, a smart city, dramatically improving the quality of life of its citizens.

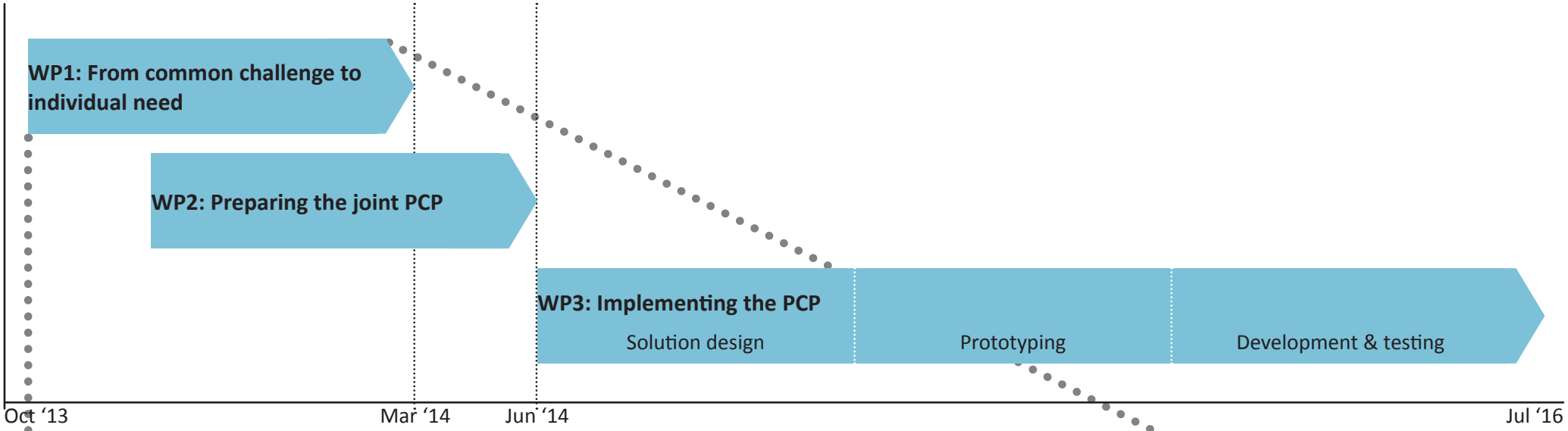
Malmö
Malmö is Sweden's third largest city and the commercial centre of southern Sweden. The municipality has had a strong focus on creating a safe, attractive and environmentally aware city, a city where the citizens feel safe using public areas. The last decade has seen Malmö consciously reinventing itself as a sustainable multi-cultural city. The local authority has given priority to activities aimed at creating a green, attractive and environmentally aware city, and has gained international recognition for its undertaken efforts.

Espoo
Located in the western part of the Helsinki Metropolitan Region and with a population of 260,000 inhabitants, Espoo is the second largest city in Finland. It has the largest concentration of science and innovation facilities in Northern Europe, belonging to the famous Otaniemi – Keilaniemi – Tapiola triangle. Espoo, together with the other cities, universities, research centres and industry in the Helsinki Region operates already as a EU Smart Region, pioneering several Europe 2020 high-level innovation developments, particularly in the field of lighting.

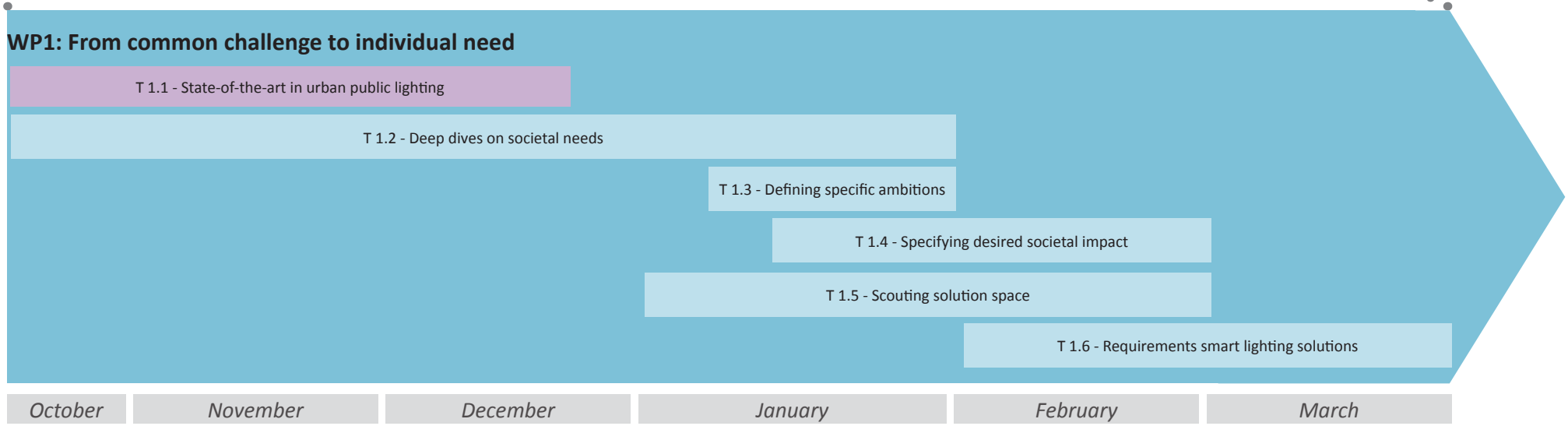
Stavanger
Located on the South West coast of Norway, the City of Stavanger and its 130.000 inhabitants represent the country's most densely populated municipality. Stavanger is the 4th largest city in Norway, known as the "Oil Capitol" since the oil industry is located here. The local authority has focus on being a healthy and sustainability city and has given priority to establish a strong green structure, where walk ways are an important part. Stavanger also underlines the importance of combining energy efficiency, urban design and public safety when it comes to upgrading of the lighting systems.

Bassano
Bassano del Grappa is a historic city belonging to the Province of Vicenza, located in the Veneto Region, in North East Italy. The management of public lighting is an increasingly important topic within the city administration, as the municipality is aiming to quickly adapt to new EU and Italian legislation in this field. Due to its cultural heritage, the city is looking to combine within its public lighting solutions energy efficiency considerations with the need to highlight its historic city centre.

Overall planning of the Pre-Commercial Procurement process of ENIGMA



Planning of WP1



Work package 1: From common challenge to individual needs

Work Package 1 starts from the defined common challenge and commences work on the definition of the state-of-the-art in innovative urban lighting solutions and the creation of a joint ambition for smart urban lighting systems, bringing together the common challenge and the 5 sets of individual needs and contexts.

This work package gathers existing experience and knowledge on societal needs and related innovation opportunities in the lighting domain from both within the partners and from other sources and use this to synthesise an ambition suitable for use across European national boundaries. This process focuses on the societal impact specification of the smart lighting solution to achieve Cities' societal ambitions.

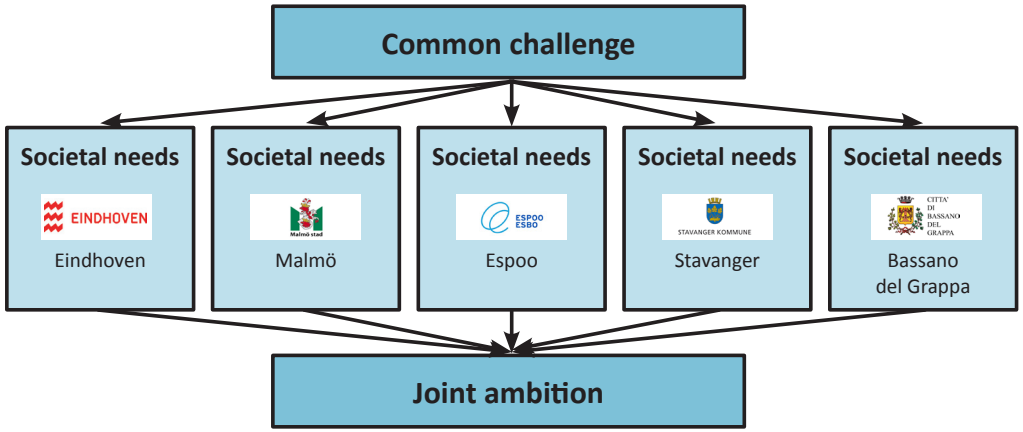
Work package 1 provides input for the preparation of the joint PCP.

Common challenge

The aim of the ENIGMA project is to procure a public lighting infrastructure as a carrier to improve societal health.

Public lighting and public infrastructure can play a significant role in achieving ambitions of cities to reach significant improvements on energy consumption, public safety and crowd control, traffic management and quality of life. Lighting is also a useful instrument in making the city an attractive place to live.

The partner cities have defined as common challenge for the joint PCP process:

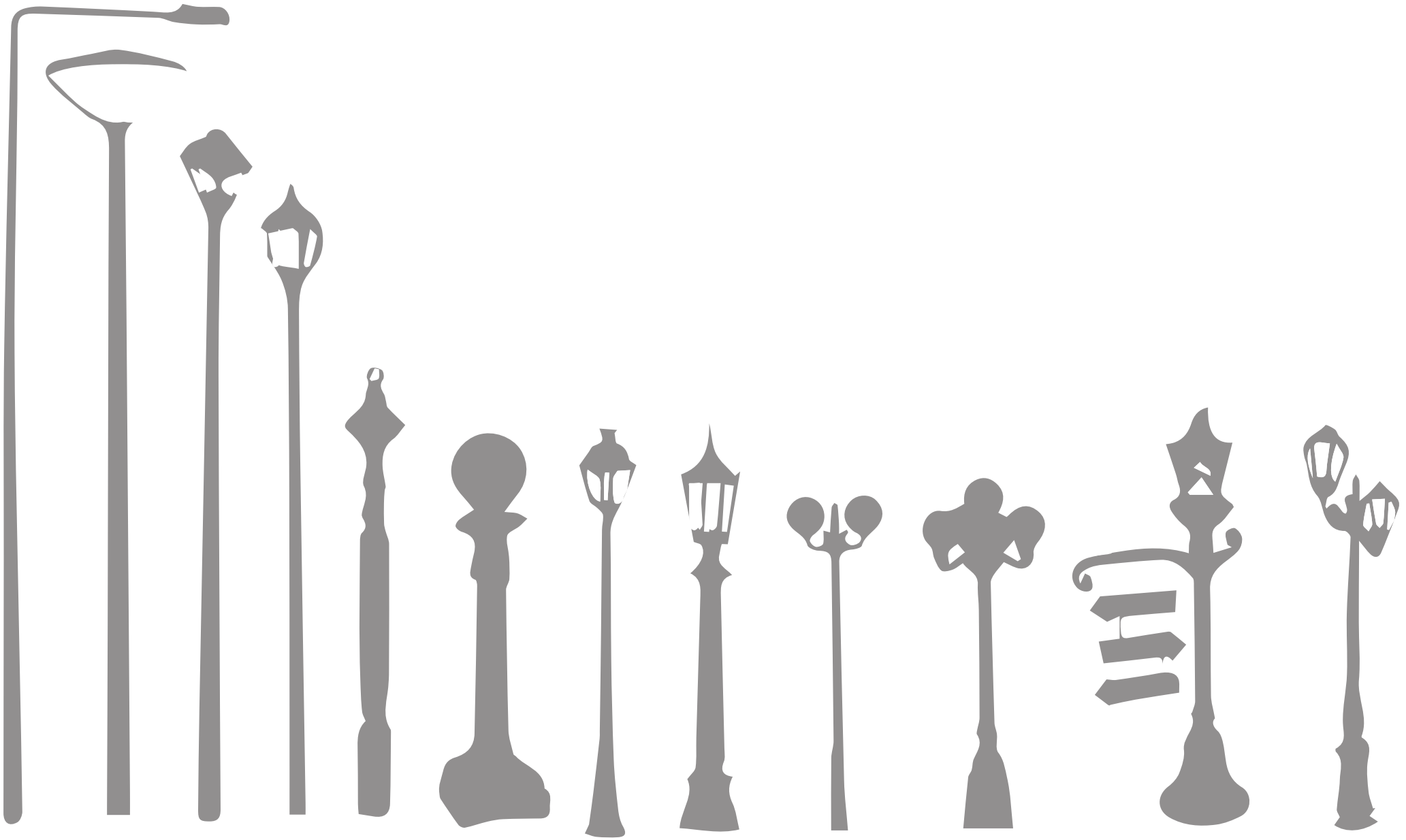


ENIGMA Common challenge
To upgrade their public lighting infrastructure and system, using ICT solutions, to enable cities to offer a wide range of intelligent and integrated services benefiting society and individual citizens and bringing the cities closer to the ambition of becoming Smart Cities.

State-of-the-art in urban public lighting

To ensure that the procurement process in ENIGMA is indeed innovative a definition of the state-of-the-art in the urban lighting infrastructure as well as in the applied procurement processes is required.

For this purpose in task 1.1 of the project interviews and questionnaires are conducted to gain insight in recently installed innovative lighting solutions in European cities. Based on the results of the online survey, best practices are selected that are reviewed on the way the solution was specified in the call and how the value of the solution was defined and evaluated. This provides insight in the current 'best practices' in procuring innovative public lighting.



State-of-the-art in urban public lighting

Task 1.1 of the ENIGMA project is to conduct interviews and questionnaires to gain insight in recently installed innovative lighting solutions in European cities. For this purpose three research methods are applied:

- Workshop to review of recent projects of the partner cities
- An online survey
- Interviews with project teams of selected ‘best practices’

This report describes the results of these activities.

Review recent projects partner cities

A workshop was conducted with the five partner cities of ENIGMA, in which they all presented a recent lighting procurement project.

In the first section of this report the results are presented.

Online survey

The survey was developed in collaboration with the ENIGMA partners and was tested with the 5 partners cities. After improvement of the questionnaire it was put online.

The survey was available online for submission in the period from 25 October to 31 December 2013. Members of LUCI and Eurocities were actively invited to participate in the survey and the ENIGMA training in Gent was used to give additional attention to the survey. Despite the effort of LUCI and Eurocities, at the date of closure only 35 registrations were done, of which only 10 were sufficiently completed to take into account in the analysis.

The second part of this report shows the results of the survey and analysis.

Best practice interviews

From the survey two interesting cases were selected for further interview.

The third section of this report shows how the procurement process for these 'best practices' was done.

Review results

In this section the results of the workshop to review recent projects of the five ENIGMA partner cities are presented.

During the State-of-the-Art Workshop that was held in Eindhoven just after the kick-off meeting of the ENIGMA project all five partner cities presented their experience with procuring public lighting solutions on the basis of a recent project in their city.

Bassano del Grappa

Introduction

Bassano del Grappa, is an historic city belonging to the Province of Vicenza, located in the Veneto Region, in the North East of Italy.

It lies between the Province of Vicenza, Padua and Treviso and at the bottom of the Alpine foothills of the Veneto Region, one of the richest Italian region (industries, SMEs, tourism, agricolture) in the Venetian Piedmont area: where important infrastructures and historical towns and industrial cities live together.

The symbol of the city is the famous Alpines' Bridge, a masterpiece of the architect Andrea Palladio, but it is also enriched by medieval remains as well as by the Venetian architecture, and moreover, it is surrounded by medieval walls.

In particular, Bassano is well known for its precious ceramics and for products DOC (controlled origin denomination), as the renowned liqueur 'Grappa'.

The lifestyle of the city is also very pleasant and full of events, the peak of which is the Opera Estate Festival Veneto when Bassano hosts a chain of great events, dance, music and theatre with renowned protagonists of the Italian and international scenes.

CITTA' DI BASSANO DEL GRAPPA

Alpines' Bridge by Palladio

Recent experience with procurement

Since the Municipal Lighting Strategy for the containment of public lighting and energy saving (developed within the Plus project, funded under the INTERREG IVC programme) entered into force only in May 2013 → no innovative procurements in terms of lighting were executed in Bassano, the investments were limited to maintenance of public lighting.

Currently the Municipality is working on the procurement to assign the lighting plan execution, in terms of requalification of the public lighting plants (mostly functional lighting), to an energy service company ESCO, through the public procurement procedure.

SUNSHINE project

Additionally, Bassano has been selected as one of the testing lighting within the SUNSHINE project (CIP-ICT-PSP-2012-6, http://www.sunshineproject.eu/about) wherein the new led dimmable solutions for the functional lighting are tested for about 70 lighting points (devices) in the city old town and the related citizenship feedback and reactions are monitored through the satisfactory reports and surveys.

Eindhoven

Introduction

Improving quality of life in the city with innovative public lighting solutions, is the ambition of the municipality of Eindhoven. The 'vision and roadmap urban lighting Eindhoven 2030' (www.eindhoven.nl/smartlight) describes this aim and aspires to inspire partners that will cooperate the coming years in applying smart lighting solutions in urban learning labs.

According to a recent publication by the European Committee 'Lighting the Cities' Eindhoven is seen as forerunner in smart lighting solutions in Europe.

The municipality would like to consolidate its role in public lighting innovation and several applications are already developed and in different states of implementation. In the bar district Stratumseind a pilot is set up to experiment and investigate the impact of lighting scenes on the mood and behaviour of visitors. At the former Philips area Strijp-S the newest lighting technologies and services are applied and tested.

The coming years more and more pilot areas will be appointed and developed to unroll the roadmap and achieve the vision for 2030.

Recent experience with procurement

Strijp-S

A 66 acre former industrial site

- Private, sodium-based, lighting installation, controlled from buildings
- Being transformed into a
- inspiring creative quarter
- Just north-west of city centre

New urban development

- 2500 new homes
- Space for small scale business activities
- Leisure and cultural facilities

Vision: Strijp-S - Creating a Public Lighting Experience

The newly transformed site of Strijp-S will have a unique, continuously developing approach to public lighting. An approach that will highlight the experience of a creative, vibrant community in an inspirational environment that thrives on a fusion of living, working and recreation.

Requirements

- Glass fiber backbone, multifunctional
- Individually, IP controlled, lighting points
- All-LED system

Requirements for each area typology:

- Functional
- Quality
- Sustainability
- Branding

The process to come from the vision to realisation contains four phases (see also picture on page 15):

Selection phase

- Market consultation through expert meetings
- Invitation to 3 designers to present a lighting concept
- Selection of designer: 3mans bv

Design phase

- Sketch design > Pre-design > Final design
- Prototyping lighting technique
- Product specification

Tendering phase

- Restricted procurement
- 6 invited, 3 proposals

Strijp-S - former 'forbidden city' (left) and development plans (above)

EINDHOVEN

Tender document:

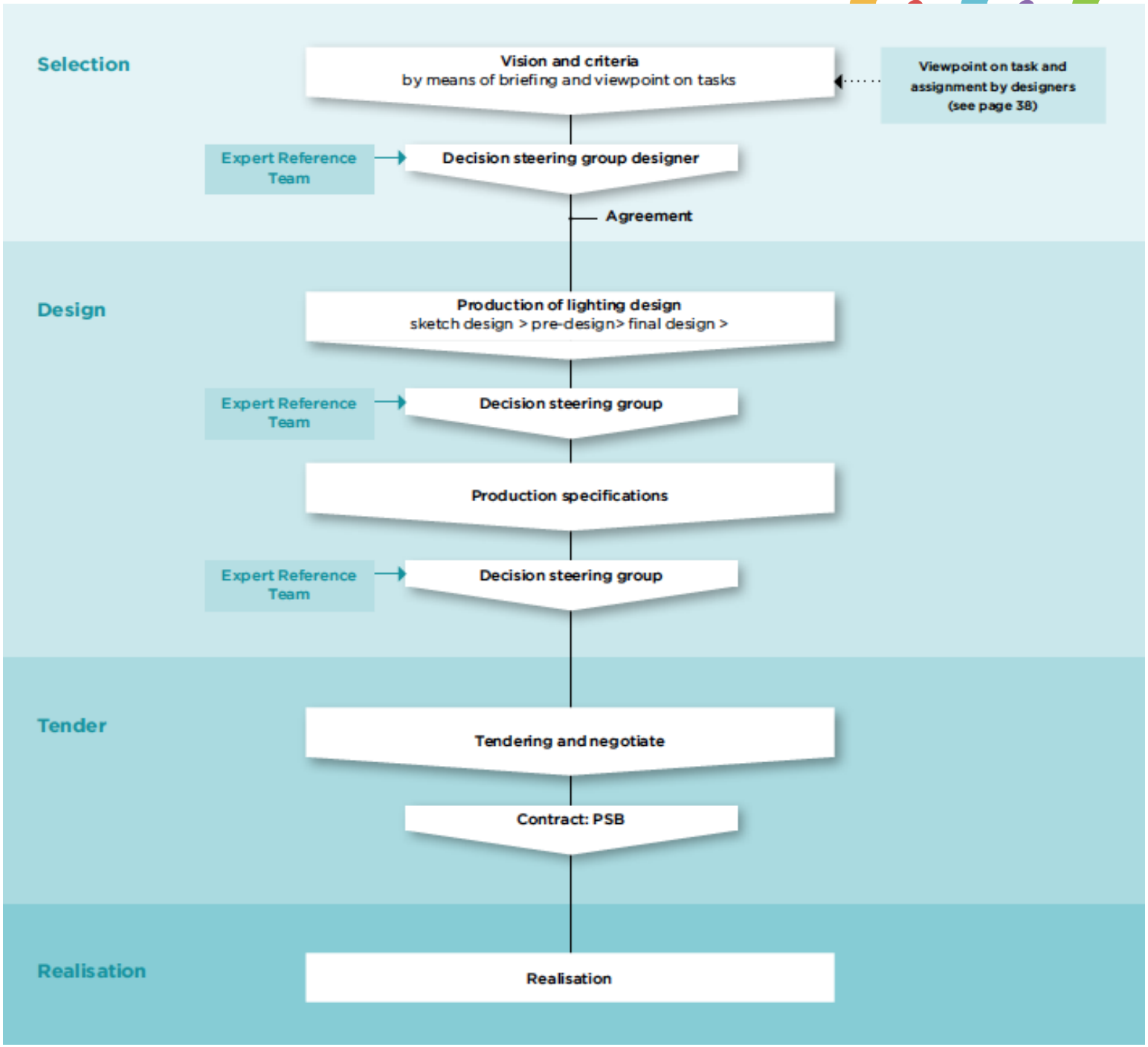
- Further development of prototype to commercial product -> description of open innovation (cooperation and innovation)
- Cost estimation for luminaires (1 pc, 2 – 50 pc, 51 – 150 pc, 151 – 300 pc)

Realisation Phase

- Test: comparision of
  - Prototype in functional luminaire
  - Prototype in commercial luminaire
  - RGB unit in commercial luminaire
- Realisation: In progress

Before: static lighting with high pressure sodium lamps

After: dynamic and intelligent innovative lighting with LED



Process to come from a vision to realisation in Strijp-S

Espoo

Introduction

Espoo is the second largest city in Finland, situated in the western part of the Helsinki Metropolitan Region. Known for Kone, Fortum, ex-Nokia, and Angry Birds Rovio. It is a fast growing urban area; at the end of 2012 there were 256760 inhabitants and 13787 employees, growing with 4000-5000 new inhabitants per year. Espoo has the largest concentration of science and innovation in Northern Europe in the Otaniemi – Keilaniemi – Tapiola –area. And home city of Aalto University centre, featuring a new campus in the future This provides an excellent focus as the test site for an European intelligent lightning project.

Espoo covers 5 large area projects:T3 in Tapiola, Espoon Keskus, Finnoo, Leppävaara, Suurpelto and Matinkylä. A new metro rail road is planned from Leppävaara to Kauklahti, with new station-based centres. Investments to infra structure cover 130 million Euros per year (not including metro, city railroad and some large road projects).

Espoo was given first prize in quality of urban spaces, specially the parks, by the society of Finnish Urban Planning Year 2012. The area also covers 95 lakes, 38 streams, 58 kilometres of seaside, archipelago,3074 hectares of Nature preservation areas, 5000 hectares of forests.

Lighting facts and expectations

- Quality Espoo Landscape architecture combines usability and functions of all the users from toddler to elderly people
- Different light atmospheres based to the usage of the area, experiences for people specially in the centres
- In certain areas minimizing light posts and special features lighting
- Soon some project examples of lighting…
- 4 seasons, snow, cold
- Sustainability/Energy saving point of view

50 000 light posts

- Over 7000 induction light posts (good color definition, lower energy usage, excellent life expectancy, 100 000 h)
- About 37000 Spns (not good colour definition, good life expectancy at 48 000 hours, easy maintenance), finding realistic alternatives for Spns in the sense of sustainability is key thing to Espoo

LED pilots

Espoo conducted several LED pilots in the past years:

- LED studies with Aalto, Year 2011 completed, 7 manufactures, 6 road light types (problems with enough lumen levels (60), sharing of light not optimal for urban areas, heating and then usage of power and shorter life expectancy)
- New Pilot in Finnoo key green area: intelligent park lighting (shuts when not needed and nobody is moving in the park pedestrian lines)
- New Finnoo area project pilot, dimmable LEDs, 100 of them in Suomenlahdentie main road, under construction with 220 metres long landscape bridge, 20 mil euros:
- 10 m high road dimmable leds, Italian AEC, about 1000 leds can be used in Finnoo
- Older centrum of Leppävaara, main square and six streets renovation, 6,4 mil euros
- under construction, Dimmable Philips Urban lower light posts and special lighting

Recent experience with procurement

- Finland has a procurement law, by which cities must organize a competition for the constructing companies to build e.g. streets, squares and parks, among detailed plans, competition documents and safety documents
- Documentation guidelines are strict about the contents and about the look
- In Espoo lighting is part of the main building contract
- Usually the cheapest offer is the winning offer
- After a written decision of the winner the infra is been done phase by phase, via monthly and weekly surveillance- and control meetings
- There are 40 companies in 18 different substance areas as consultants of planning, years 2013-2014 + 2 optional years, procurement process was done via law in year 2011-2012
- 42 specialists in infra planning department as users of consultants, some of them are project secreters (areas of streets, roads, bridges, green areas, sport areas, forests, environmental technics, accessibility, traffic safety, bicycling)
- Infra Planning Department also constructs green areas and streets for about 25 mil euros per Year

Functions of all the users, living room in a deck

Different light atmospheres based to the areas and the usage of the area

Minimizing light posts and special features lighting

Poulsen surface Pharo installated lights for entrance terasses and its vegetation

Poulsen Kipp Induction 5 m for play and sports, deck installation with cables

Poulsen wall lights designed for Espoo, pedestrian lines next to library and its cortyard

Shared space Street model Espoo, refined column, Schreder Saphir, Spn

- Consultant companies have lighting specialists of typically buy the lighting design from certain specialized subconsultants

The roundabout connecting Finnoontie and Kuitinmäentie roads

Malmö

Introduction

Malmö, a city in the south of Sweden has 300 000 residents, of which 30% are born abroad in 175 different countries and 48% of the population is less than 35 years old. Malmö is making the transformation from industrial town to knowledge based city. The municipality organization Malmö Stad has 20 000 employees.

The Department of Internal Services takes care of for example maintenance and care of streets, parks and real estate, emergency work, technical services and school restaurants .

The Business unit Municipal Properties manage the city owned buildings such as schools, kindergartens, elderly care, residential care, cultural and recreational properties. In total 1.6 million square meters.

Malmö was elected Green City of the year in Sweden both 2010 and 2013 and has a goal to become climate neutral in 2020 and to use 100 % renewable energy in 2030.

Recent experience with procurement

Stångbönans preschool

The project involves renovation and expansion of a preschool, where the main goal has been an energy-efficient and flexible building that is easy to manage and use.

Most of the lighting consists of LED's with DALI actuators, controlled by a KNX system.

All primary areas are possible to dim and are prepared for constant light control.

In addition to lighting control KNX system even heating, ventilation and electrical outlets.

Examples of functions in the KNX system

Kv Stångbönan 2, Malmö Stad

in a range of specific areas.

Corridors

- Lighting is controlled on / off through signal from burglar alarms connected KNX system and lights controlled via KNX presence detectors in each room.
- Lightning illuminates up to 20 % light level when the staff turns off the alarm.
- When presence is detected in each room the lighting is controlled to 100 % brightness.
- When no presence is detected in each room the lighting is controlled to 20 % brightness.
- When the staff turns on the alarm for the night all lights goes off.

Classroom

Lighting:

- Lighting is switched on/off manually via the KNX pushbutton panel.
- The lighting dimming up/down via KNX pushbutton panel.
- Lighting is switched off when no KNX presence detector in space is not detected any movement for 15 minutes.
- It is possible to constant dim room with a setpoint of 500 lux.
- When the staff turns on the alarm for the night all lights goes off.

Socket outlets:

- Outlet within the space is controlled over KNX presence detector.
- When presence is detected, socket is energized and when KNX presence detector in space is not detected any movement for 15 minutes the power goes off again.

Heat:

- The heat is controlled via KNX room thermostat and via KNX presence detector.
  - Setpoint if detected presence in the room and the windows are closed = 19° C
  - Setpoint when no presence in the room are detected and the windows are closed = 21° C
  - Setpoint if windows are open = 10 ° C
- Absence signal will be delayed by 10 minutes.

Ventilation

- Ventilation is controlled via KNX presence detector and via KNX CO_2 sensors:
  - Detected presence in the room, open air dampers to the maximum level.
  - If no presence is detected, ventilation dampers close to minimum level.
  - If the measured CO_2 level raise above 800 ppm, ventilation dampers open to maximum.
  - In case of open windows, ventilation dampers close to minimum level.
- Absence signal will be delayed by 10 minutes.

Baltic Hall & Ice Stadium

Replacement of facade and entrance lighting.

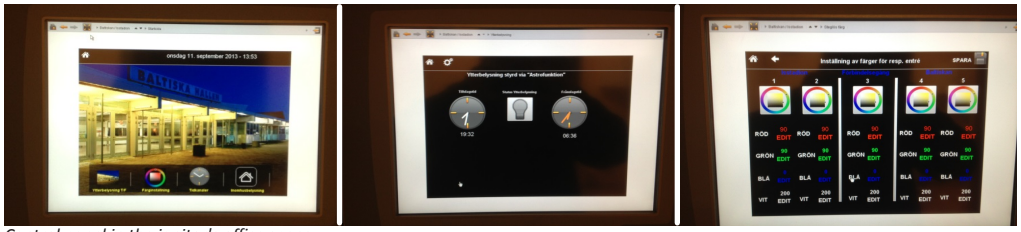
As part of the renovation of the Ice Stadium for the upcoming Junior World Ice Hockey Championship 2013-2014 , the City of Malmö decided to change the façade and entrance lighting at the facility.

The goal was to create an energy-efficient and exciting lighting of the arena's distinctive façade:

- As floodlight there has been a white LED luminaire installed, and as entrance lighting a RGBW luminaire was installed.
- The lighting is controlled by an astronomical clock and via a touch panel in the janitor's office space.
- In normal mode when no events are going on, all of the lighting is in white color, and when there are a event the caretaker can set any colour individually for each entrance depending on what entrance colour has been printed on each ticket.
- As a control system for the plant is a KNX system that communicates with each luminaire via DALI.

This enables any bounce for lamps and ballasts can be presented in plain text for users , making debugging and maintenance can be carried out efficiently.

In comparison with the previous exterior lighting the city today saves almost 16,000 kWh / year.



Control panel in the janitor's office space

Baltic Stadium before

Baltic Stadium after (below)

Stavanger

Introduction

Stavanger is a city on the south-west coast of Norway, with a population of approximately 130 000 inhabitants in an area of 71 km², making it the most densely populated area in the country. It has a mild coastal climate with significant precipitation. The average temperature during the winter is -2.6 ºC . Snow is infrequent. Being this far north the autumn and winter is long and dark – with dark mornings and evenings.

Stavanger has approx. 160 km with gravelled or paved pedestrian walk ways – of this approx. 100 km is lit up. The amount of illumination depends on type of walk way, area, and type of lighting source. Existing lighting has varying height and type of armature. In new projects – parks and open areas – pole height is 4-5 m using LED technology. The width of the roads are 2.5-3 m with gravelled or paved surface.

The local authority strives to improve its local lighting system and underlines the importance of combining energy efficiency, urban design and public safety considerations when planning the upgrade of its systems.

Stavanger cathedral, Byparken, Kongsgård and Stavanger Forum

Roles in the project:

- Stavanger Municipality - is the owner and administrator of the public lighting in both areas
- Rambøll - the idea and design of the lighting plan for the cathedral area
- Zenisk - the idea and design of the lighting plan for Stavanger Forum
- Lyse - municipal owned company that builds and operates outdoor lighting

Stavanger Cathedral, Byparken and Kongsgård

Stavanger Cathedral, Byparken and Kongsgård are located in central Stavanger. The overall concept in this project springs from the fact that the cathedral is the most important building in the city. The lighting reflects this by lighting the vertical surfaces of the cathedral, and by cooling the light temperature in the surrounding areas.

Lighting installation:

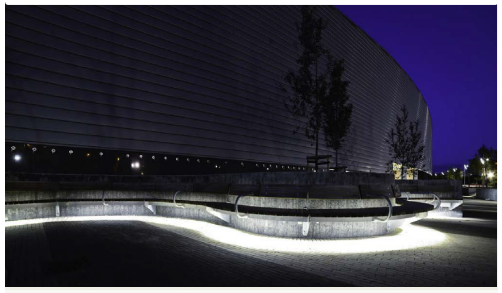
- 16 different luminaries and lamps
- Fiber optik, metal halogen, halogen, LED
- Stavanger-lamps and Breiavann-lamps were rebuilt with metal halogen in 2011. We are now rebuilding them with LED.

Stavanger cathedral before (pictures on top) and after (picture below)

Procurement process:

- Parts of the project was sent on a tendering process on DOFFIN.
- The Stavanger-lamp, the Breiavann-lamp and the Hess-lamp were all purchased directly from the produser SUGG and Hess.
- The Ministry of Government Administration has created a comprehensive guide where the primary target is purchasers in the public sector and for companies that deliver to the same

STAVANGER KOMMUNE



sector.

- The law says that the regulations will "contribute to the public acts with integrity, so that the public can have confidence that public procurements are made in a socially beneficial way." In order to build demand for orderly procurement processes, the guidance thorough handling of the principles of equal treatment, predictability, transparency and competition.

Stavanger Forum

Stavanger Forum is a large area that is planned and designed for exhibitions, conferences, sporting venues and events. When the area is fully developed, it will extend over a length of 800 meters and includes hotels, arenas, halls, parks, squares and traffic areas.

The light design helps to bring the area together and makes it appear coherent.

The light design gives a special identity to the landscape as it has focus on aesthetic and stylish solutions.

A new main walkway was established with custom made lighting columns called Gras.

These lighting columns are based on a prototype from Copenhagen, and are further developed by Phillips in cooperation with the light designer and the architect. There is special effect lighting on some of the buildings facades and under benches.

The surrounding streets and the bicycle lanes, are given another kind of armatures and poles, but is especially chosen for this area.

Main goals: Value barometer - Stavanger cathedral, Byparken and Kongsgård

Identity and beautification of the city - Marking unique city elements (as a total image as in the previous picture, but also as individual elements): buildings, the water's edge, paths and pavements, water spouts, stone fences, ruins, sites and furnishing, trees and especially plantings, etc. - An authentic narrative of the historical city - Emphasizing the architecture surrounding monuments and art	**5**
Personal safety - Safety and wellbeing: "I like to move around in and spend time in this place both during the day and at night"	**4**
Safety and orientation - The area is readable; paths, places, resting points and historical sites are easy to identify. The area is easily navigated, also for visually impaired	**4**
Locale and social activities - Attracting more "guests" to the area, which will create a setting which invites dynamics, community and communication - Longer and social visits to the area, even during the winter months for larger parts of the population as well as for tourists	**3**
Larger economic gain for the city - An active and thriving city generates new business possibilities and an economic profit	**3**
Environmentally friendly - Reduced light pollution and visual chaos - Non blinding lights	**2**
Installation- and maintenance-friendly solutions - Available for fittings and installation for quick and frequent cleaning and maintenance	**2**
Sustainability and energy use	**1**
Traffic and movement safety - Room for all types of traffic in a prioritized order, pedestrians – cyclists - cars	**1**

Equipment Stavanger Forum:
Along the walk way:

- Poles with a iGuzzini MaxiWoody Compact with 35 W and 70 W HIT light source.
- Philips Gras poles with 19 LED Lamp

In between the buildings:

- Flash poles with Maxi Woody Compact 35 W HIT (with both flood and spot optics)

The facade of the New Stavanger Ice Hall:

- LED star Sienna (1.2 W)
- G-Flexible LED strip (mounted in aluminum)
- This is controlled via an: cue Butler XT controller

Conclusion

During the workshop a number of learning points were defined, as well as some open questions:

Learning points

- Seek cooperation with all stakeholders in the quadruple helix
- Perform public consultation in all phases of the project
- Include citizens, universities, companies, municipality, ...
- Budget is a challenge, often costs increase during the project
- It is important to have project sponsor (e.g. alderman)
- Lighting should be integral part of landscaping (and be addressed in this stage already, not just after the landscape architect is 'ready')
- Stay focused on functions, not the (technical) solution
- A market consultation step in the process can be very enriching
- There is a need for cooperation within procurement processes

Questions

- Who defines and decides upon needs?
- How do we get citizens to react on policies (they find it difficult)?
- How do we involve different citizen groups?
- How can we acquire and share true lighting know-how and design process?

Survey results

In this section the analysis of the completed survey submissions is presented. In total 35 respondents registered for the survey, but only 10 cities completed the survey. Only European cities were asked to participate. Please take note that the total amount of completed surveys is only 10, which means that the results are not representative for all European cities.

The survey existed of five parts:

- General questions on the city (3 questions)
- General questions on the installed lighting systems (8 questions)
- Specific questions on a recently installed lighting system (5 questions)
- Specific questions on a recent procurement project (18 questions)
- General questions on the future of public urban lighting in the city (7 questions)

General questions on the city

In this section participants were asked to provide some general information on their city.

Only European cities were asked to participate. The division of the cities over the European countries is given in figure 1.

The participants were asked to indicate the number of inhabitants in the municipality, choosing one of the categories:

- less than 25 000
- between 25 000 and 100 000
- between 100 000 and 250 000
- between 250 000 and 1 000 000
- more than 1 000 000

Figure 2 shows that none of them were either very small or very large cities.

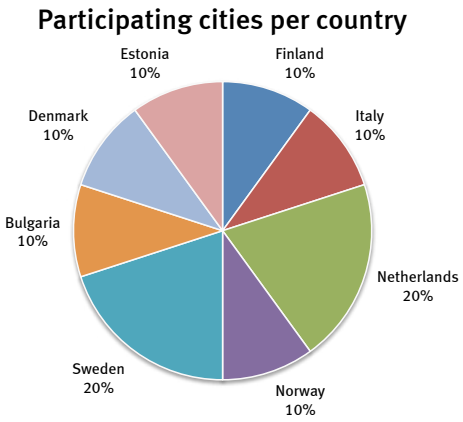


Figure 1 - Participating cities per country

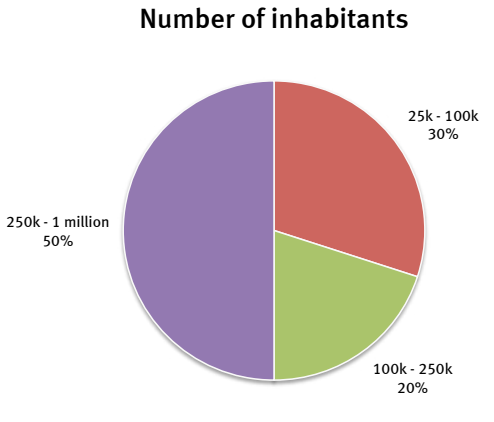


Figure 2 - Number of inhabitants of the participating cities

General questions on the installed lighting systems

In this section participants were asked to provide some general information on the current lighting system installed within their municipality.

The participants were asked to indicate the total number of light points within their city limits, choosing one of the categories:

- less than 2 500
- between 2 500 and 10 000
- between 10 000 and 25 000
- between 25 000 and 100 000
- more than 100 000

One city was not able to answer this question. Figure 3 shows the results for the other cities.

The participants were asked to indicate the total amount of power of the lighting system, choosing one of the categories:

- less than 1 MW
- between 1 and 3 MW
- between 5 and 10 MW
- between 3 and 5 MW
- more than 10 MW

Two cities were not able to answer this question. Figure 4 shows the results for the other cities.

The participants were asked to indicate the annual total amount of energy used for the lighting system, choosing one of the categories:

- less than 2 GWh/year
- between 2 and 10 GWh/year
- between 25 and 50 GWh/year
- between 10 and 25 GWh/year
- more than 25 GWh/year

One city was not able to answer this question. Figure 5 shows the results for the other cities.

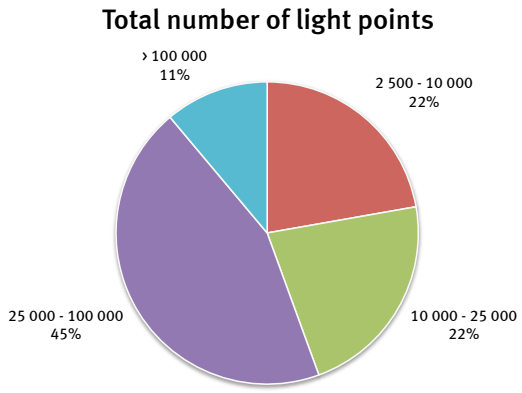


Figure 3 - Total number of light points within the city limits

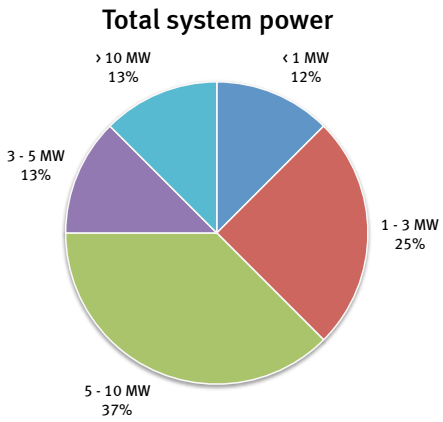


Figure 4 - Total amount of power of the lighting system

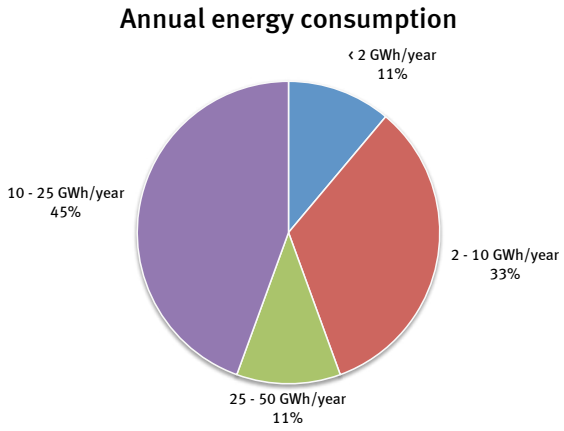


Figure 5 - Annual total amount of energy used for the lighting system

The participants were asked to indicate the average cost for 1kWh - excluding the cost for infrastructure, including tax (if applicable), choosing one of the categories:

- less than 0.02 €
- between 0.02 and 0.05 €
- between 0.05 and 0.10 €
- between 0.10 and 0.15 €
- more than 0.15 €

Figure 6 shows the results.

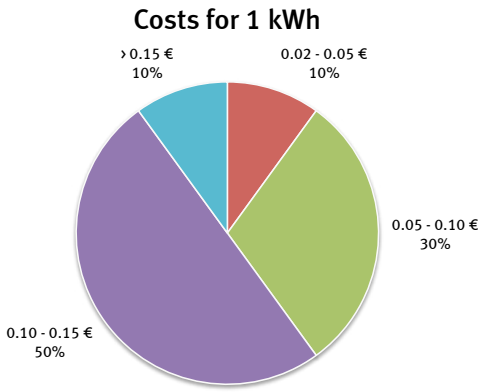


Figure 6 - Average cost for 1kWh excluding infrastructure, including tax (if applicable)

The participants were asked to indicate the average age of the light points by indicating the percentage in each of the categories:

- less than 10 years old
- between 10 and 20 years old
- between 20 and 30 years old
- more than 30 years old

Figure 7 shows the division of the age of the total amount of installed light points.

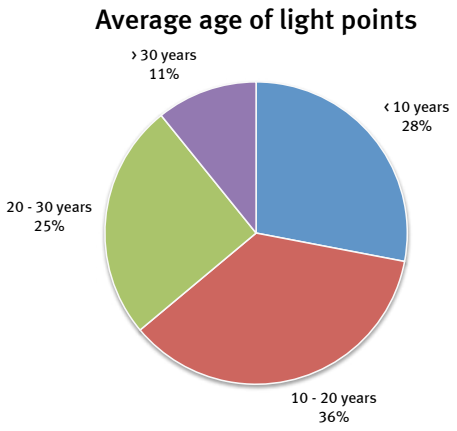


Figure 7 - Average age of installed light points in the cities

The participants were asked to indicate the type light source technology for the light points within the city limits by indicating the percentage in each of the categories:

- Metal halide
- Mercury
- Sodium high pressure
- Sodium low pressure
- Fluorescent
- Incandescent
- Induction
- LED
- Other

Figure 8 shows the division of the light source technology of the total amount of installed light points (excluding the city that was not able to indicate its total number of light points). Incandescent and induction both have 0%.

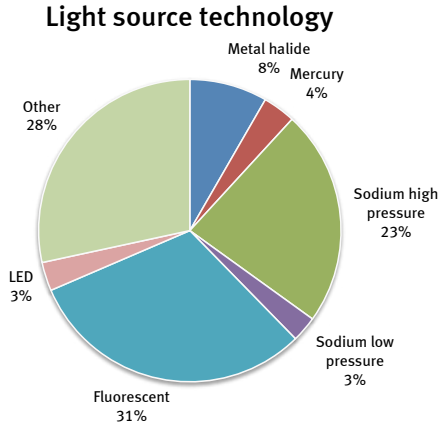


Figure 8 Light source technology installed within the cities

The participants were asked to indicate the type of controls they have installed for the light points, choosing all that apply from of the categories:

- Centralized control
- Photoelectric cell
- At the supply point
- Clock
- Astronomical clock
- Remote control by SMS command
- Remote control by radio frequency (RF)
- Remote control by power line communication (PLC)
- Remote control by internet protocol (IP) or wifi
- Other

Figure 9 shows the division of the age of the total amount of installed light points. Two cities indicated the category 'other' and specified it as electricity dividing boxes and RSMP respectively.

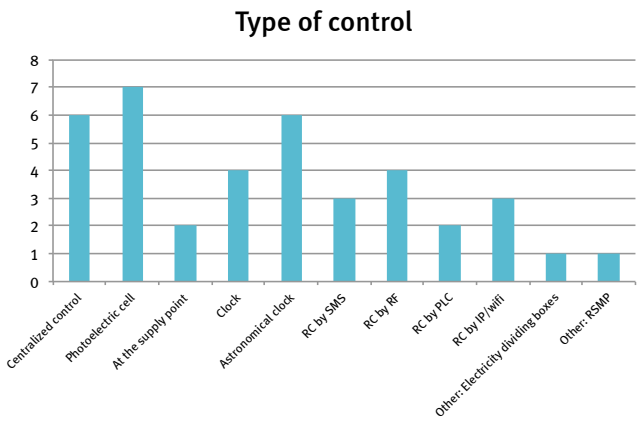


Figure 9 - Type of control for light points in the cities

The participants were asked to indicate which energy saving measures they apply, choosing all that apply from of the categories:

- Dimming on predefined time intervals
- Dimming based on presence sensors
- Extinghuising of light points
- Extinghuising of specific applications
- Extinghuising of lamps at multi-lamp luminaires
- Replacement with energy efficient solutions
- None
- Other

Figure 10 shows the division of the age of the total amount of installed light points. One city indicated the category 'other' and specified it as the upcoming use of LED.

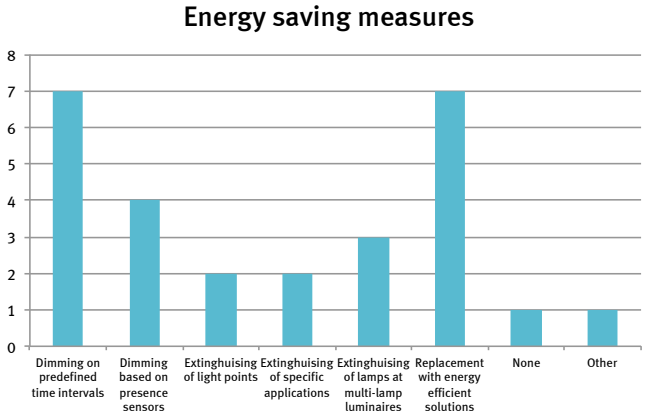


Figure 10 - Energy saving measures applied by the cities

Specific questions on a recently installed lighting solution

In this section participants were asked to select a recently installed lighting solution in their city, selecting one of the installations that was completed not too long ago and answer the following questions with that project in mind.

The participants were asked to indicate in what functional area the lighting solution is installed, choosing all that apply from of the categories:

- Residential area
- Through road / main road
- Shopping district
- Entertainment area
- Outdoor parking
- Nature / Park
- Industrial area
- School area
- University campus
- Sports area / playing field
- Cultural heritage
- Other

Figure 11 shows the results. The areas specified in the category 'other' are: centrum, green areas, small roads and squares, office, changing the lighting on the main roads crossing throughout the whole city, and busstation.

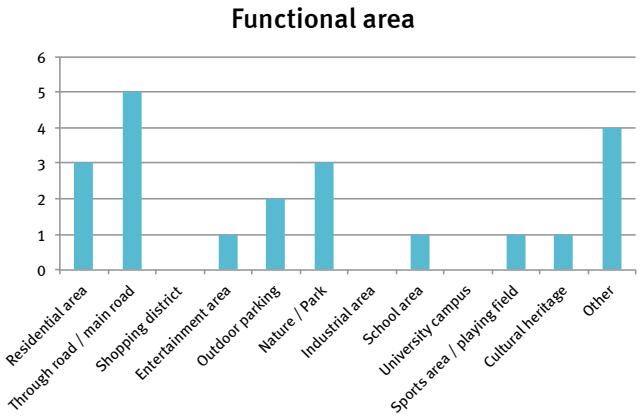


Figure 11 - Functional areas in which the lighting solutions are installed recently

The participants were asked to indicate the size of the installed lighting system by the total number of light points, choosing one of the categories:

- less than 10 light points
- between 10 and 100 light points
- between 100 and 500 light points
- between 500 and 2 000 light points
- more than 2 000 light points

One city was not able to answer this question. Figure 12 shows the size of the installed lighting systems, indicated by the total number of installed light points.

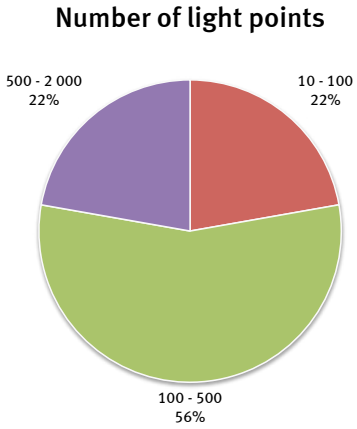


Figure 12 - Size of the installed lighting system, indicated by the total number of light points.

The participants were asked to indicate the type light source technology for the light points within the system by indicating the percentage in each of the categories:

- Metal halide
- Mercury
- Sodium high pressure
- Sodium low pressure
- Fluorescent
- Incandescent
- Induction
- LED
- Other

Figure 13 shows the division of the light source technology of the installed light points (excluding the city that was not able to indicate its total number of light points). LED is by far the most used technology.

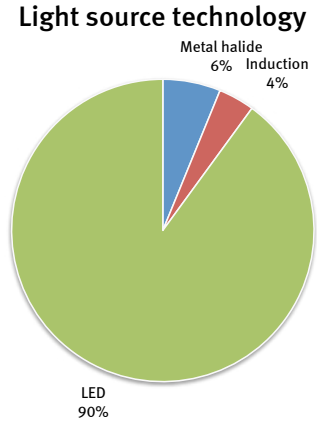


Figure 13 - Type of light source technology applied in the systems

The participants were asked to indicate the type of controls they have implemented in the system, choosing all that apply from of the categories:

- Centralized control
- Photoelectric cell
- At the supply point
- Clock
- Astronomical clock
- Remote control by SMS command
- Remote control by radio frequency (RF)
- Remote control by power line communication (PLC)
- Remote control by internet protocol (IP) or wifi
- Other

Figure 14 shows the division of the age of the total amount of installed light points. Two cities indicated the category 'other' and specified it as KNX and diverse sensors respectively.

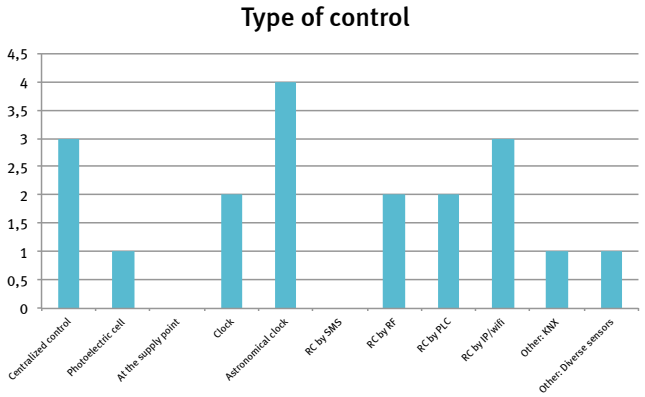


Figure 14 - Type of control implemented in the systems

Specific questions on a recent procurement project

In this section participants were asked to use the same lighting installation as in the previous section, and to answer the questions on the procurement process with this project in mind.

The participants were asked to indicate the main reason to start the procurement of the lighting system, choosing the most important one of the categories:

- It was part of the implementation of a long term plan or master plan
- It was part of a regular maintenance or replacement schedule
- It was part of an improvement or upgrade of the area
- It was a new development / not planned

One city was not able to answer this question. Figure 15 shows the results for the other cities.

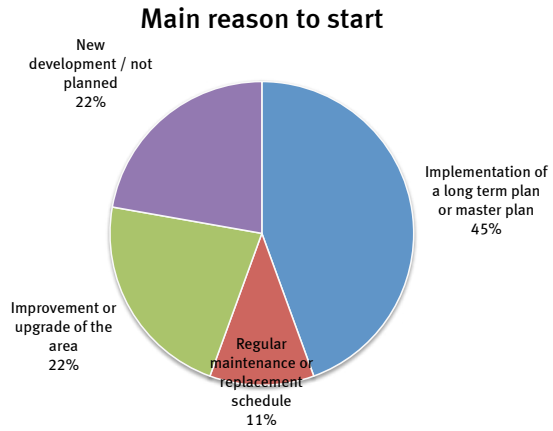


Figure 15 - Main reason to start the procurement of the lighting installation

The participants were asked to indicate the main reason to start the procurement of the lighting system, choosing the most important one of the categories:

- Cost
- Sustainability
- Economics
- Social / societal
- Technology

One city was not able to answer this question.

Subsequently the participants were asked to indicate what the starting point was from which the target on the main driver was defined.

For cost reduction they could choose one of the options:

- Investments in the system: e.g. Costs of lamp posts, luminaires, light sources, power supply units, controls
- Total cost of ownership: including maintenance/replacement costs and energy savings
- Total value: integral value of lighting for economical, social and ecological aspects
- Other

For sustainability they could choose one of the options:

- Adhering to the regulations and rules set by local and European governments
- Material use and energy consumption in the total product lifecycle
- Ecological effectiveness of public and private lighting systems (taking all lighting in the city into account - not only the system for which the municipality is responsible)
- Social and ecological sustainability
- Quality of life in public space as a whole
- Other

For economis they could choose one of the options:

- Increasing attractiveness of the city for the citizens in the evening and night
- Increasing tourism through promoting heritage
- Increasing economic activity by attracting new business (hotspot)
- Other

For social/societal they could choose one of the options:

- Increase road safety
- Increase social safety
- Increase social cohesion
- Increase health & wellbeing
- Other
- For technology they could choose one of the options:
- Technical end-of-life of previous system
- Availability of new infrastructure
- Availability of new hardware / devices
- Availability of new software or software platform
- Other

Figure 15 shows the results of the main reason as well as the starting point from which the targets were defined.

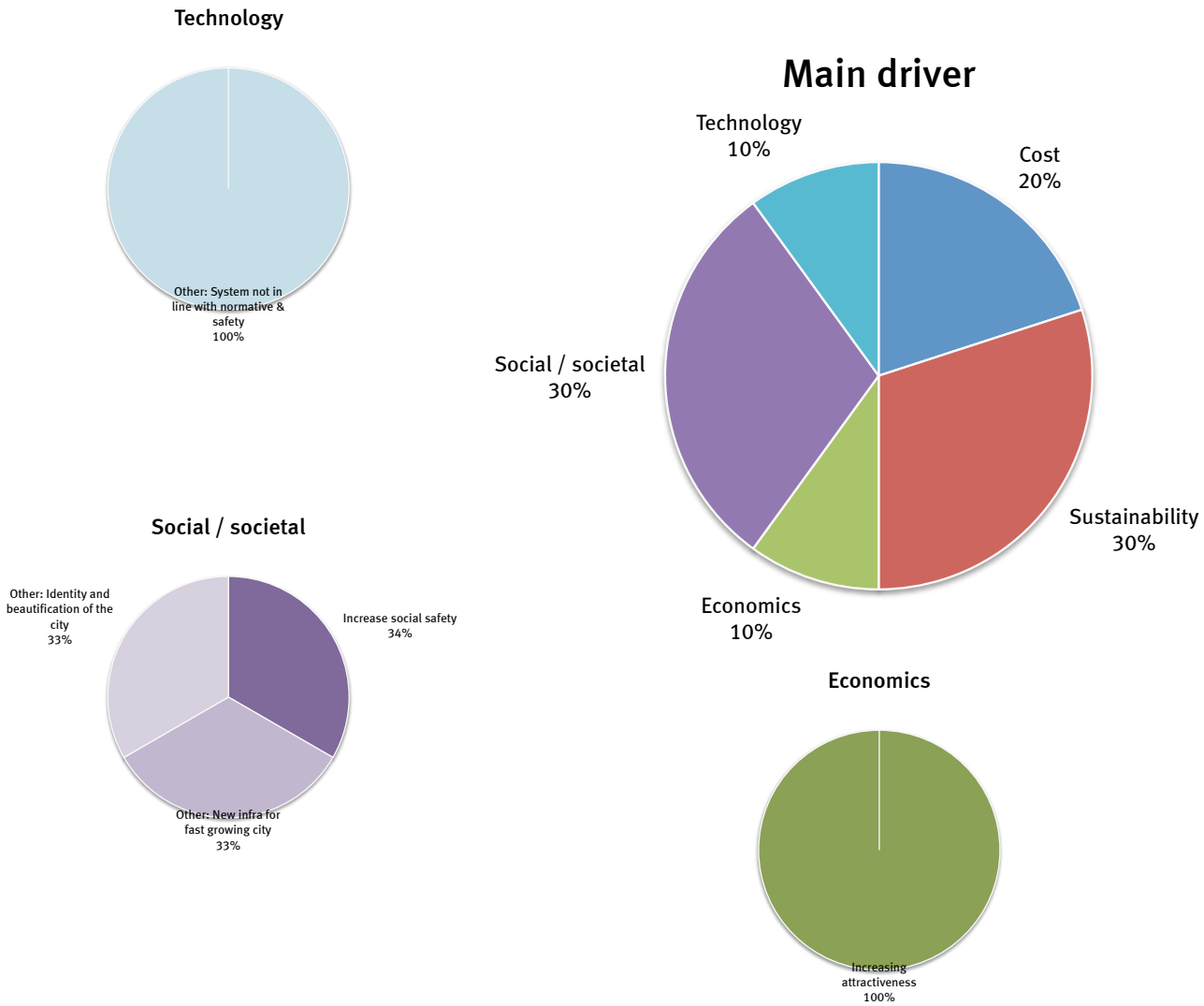


Figure 15 - The main driver for the procurement project together with the starting points from which the targets were defined

The participants were asked to name the three most important needs defined in the project, in free text format. One city did not answer this question.

1 2 3

The answers on number 1 were:

- Increase public safety
- Public safety
- Sustainability
- Identity and beautification
- Innovation
- Street lighting with full monitoring and management of individual light points
- Change the outdated lighting system to new technology with high lighting quality and energy efficiency
- Most energy efficient solution
- Opportunities with LED technology

The answers on number 2 were:

- Increase visual experience
- Adaptations to the new lighting regulations
- Social needs
- Safety
- Sustainability
- Reducing operational costs, consumed electrical energy and CO2 emissions
- Use lighting as a way of creating new industry and public-private-research partnerships in the city and establishing a green lab
- Low maintenance costs
- Which light levels can meet the requirements

The answers on number 3 were:

- Public interaction
- Sustainability and energy/cost efficiency
- Technological (LED pilots)
- Attract people
- Interaction people - environment
- Improving the road safety during the dark part of the day
- The vision of the long-term project is to be a frontrunner municipality for sustainable lighting and smart city solutions
- Remote control of function of the lamps
- Which light levels we fulfil

The participants were asked to indicate how the needs were defined in the project, choosing all that apply from of the categories:

- Policy makers / strategy department
- Project team
- Internal expert
- Involvement of citizens
- Involvement of external stakeholders
- Other

Figure 16 shows the results.

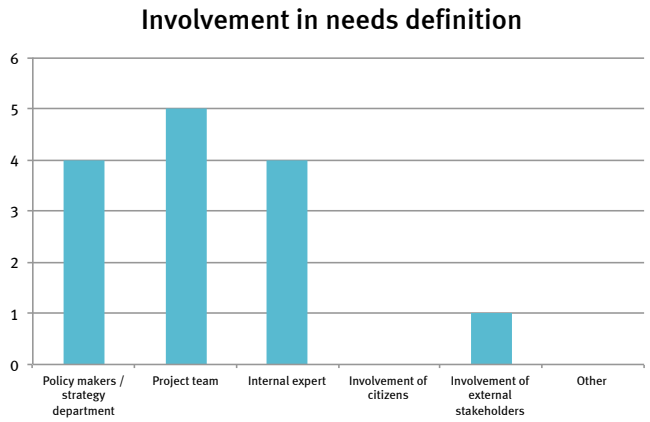


Figure 16 - Needs definition

The participants were asked to name the three most important specifications for the desired lighting solution, in free text format.

Two cities did not answer this question.

1 2 3

The answers on number 1 were:

- Lighting technology
- To respect the needs defined
- Long life expectancy
- Temperature of the light
- All LED
- Energy efficient lighting quality
- All lamp must be replaced by led
- To meet normal lighting requirements with cost-effective implementation as good examples of solutions

The answers on number 2 were:

- Technology for controlling the lighting installation
- To use the LED solutions
- Intelligent light where it is needed, function-based
- Individually controlled
- Safety and security in the urban space
- Remote control system by RF

The answers on number 3 were:

- Maintenance costs
- To respect the project budget
- Enough lumen (60) not too much heat
- Connection/combination with fiber/wifi/sensors
- Sustainability
- Best TCO-outcome of comparing armatures

The participants were asked to indicate the types of evaluations done in the project, choosing all that apply from of the categories:

- Measuring if the solution was according to the specification
- Testing if the needs were met
- No (formal) evaluation was done
- Other

Figure 17 shows the results.

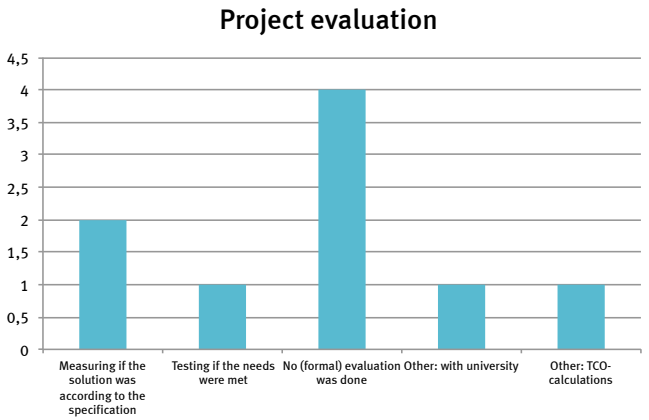


Figure 17 - Types of evaluation done in the project

The participants were asked to indicate the scope of the solution they purchased, choosing one of the categories:

- Public lighting
- Public lighting in combination with other lighting related functions (e.g. illumination of heritage, or interactive lighting)
- Smart system including non-lighting related functions (e.g. traffic management, internet-of-things)

Figure 18 shows the results.

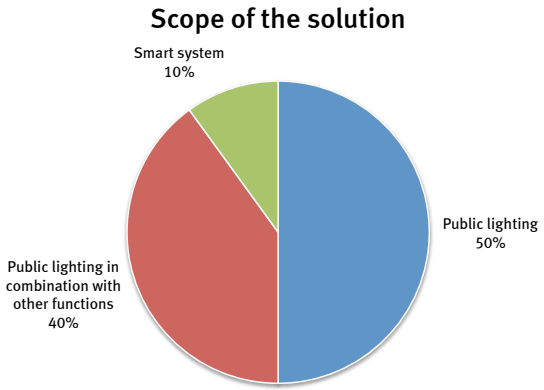


Figure 18 - Scope of the solutions purchased

The participants were asked to indicate the type of solution they purchased, choosing the most suitable description of the categories:

- Standard functional product
- Standard product for function and experience
- Standard service
- Newly available product
- Newly available product for function and experience
- Newly available service
- Customized solution
- Innovative solution requiring research and development

One city did not answer this question. Figure 19 shows the results for the other cities.

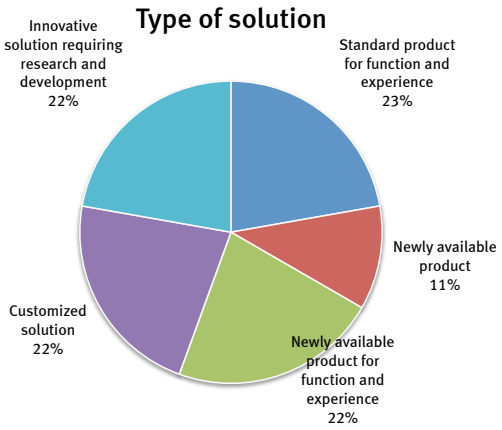


Figure 19 - Type of solution purchased

The participants were asked to indicate the type of procurement procedure they applied, choosing one of the categories:

- Open procedure: any interested economic operator may submit a tender
- Restricted procedure: any economic operator may request to participate and only candidates invited to do so may submit a tender
- Negotiated procedure with prior publication: the contracting authority consults the economic operators of its choice and negotiates the terms of the contract with them
- Negotiated procedure without prior publication: the contracting authority consults the economic operators of its choice and negotiates the terms of the contract with them without prior publication of a contract note
- Competitive dialogue: the contracting authority publishes a notice and receives requests to participate on which selected candidates are invited to conduct a dialogue (often in several stages), at the end candidates submit final tenders
- Public works concession
- Service design contest
- Other

One city did not answer this question. Figure 20 shows the results for the other cities. One city chose 'other' and specified it as OPI.

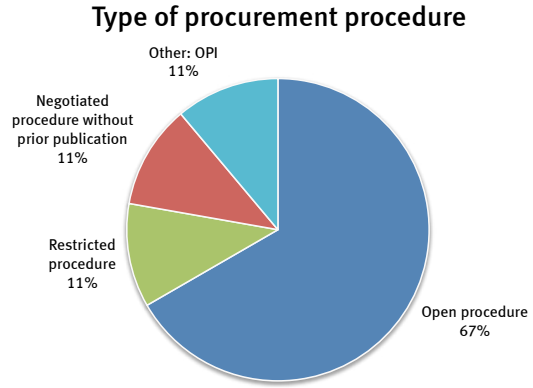


Figure 20 - Type of procurement procedure applied

The participants were asked to indicate what was included in the offer, choosing all that apply from of the categories:

- Design
- Build
- Maintain
- Operate
- Finance
- Demolish
- Recycle
- Other

Figure 21 shows the results.

The participants were asked to indicate what award criteria were used to evaluate proposals from market parties in the selection process, choosing all that apply from of the categories:

- Price
- Most economically advanced tender (MEAT)
- Other

Figure 22 shows the results. One city chose 'other' and specified it as OPI - energy efficient and innovative.

The participants were asked to indicate if whole life costing was considered in the procurement phase, choosing one of the categories:

- Yes, we used whole life cycle costing in the procurement phase
- No, we did not use whole life cycle costing in the procurement phase
- We used other method(s)

Figure 23 shows the results.

Figure 21 - Elements included in the offers

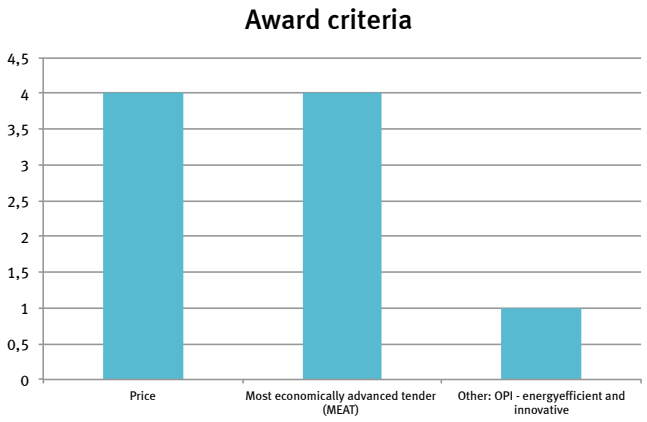


Figure 22 - Award criteria used to evaluate proposals in the selection process

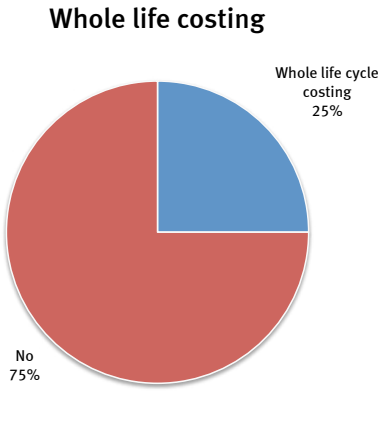


Figure 23 - Application of whole life cycle costing in the procurement phase

The participants were asked to indicate what type of supplier was selected, choosing one of the categories:

- Partner
- Preferred supplier
- Known supplier
- New supplier

Figure 24 shows the results.

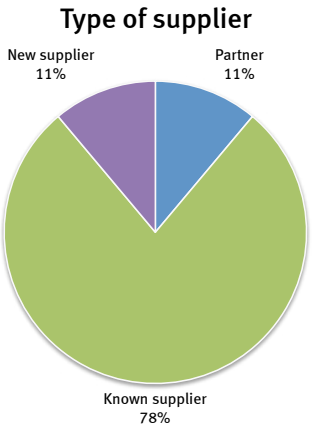


Figure 24 - Selected type of supplier

General questions on the future of public urban lighting

In this section participants were asked to provide some insight in the future ambitions of the city with respect to public urban lighting.

The participants were asked to indicate how satisfied they are with the current lighting system in the city, choosing one of the categories:

- Very satisfied
- Somewhat satisfied
- Neither satisfied nor dissatisfied
- Somewhat dissatisfied
- Very dissatisfied

Figure 25 shows the results.

The participants were asked to indicate their ambition regarding public lighting, choosing one of the categories:

- We have no specific ambitions for the longer term
- We would like to maintain the current level
- We would like to apply some new lighting solutions that have been proven elsewhere
- We would like to apply some new lighting solutions that have not yet been proven elsewhere
- We would like to explore new opportunities through experimental projects

Figure 26 shows the results.

The participants were asked to indicate what they think could be valuable applications of innovative lighting solutions, choosing all that apply from of the categories:

- Illumination of roads and paths
- Tool for urban planning
- Creating value and wealth for the city
- Attracting investments
- Promoting heritage
- Changing perceptions
- Bringing in new partnerships
- Other

Figure 27 shows the results. One city chose 'other' and specified it as Lighting as infrastructure for services and apps.

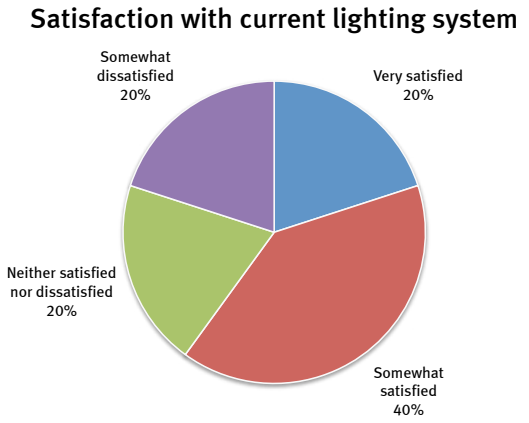


Figure 25 - Satisfaction with the current lighting systems in the city

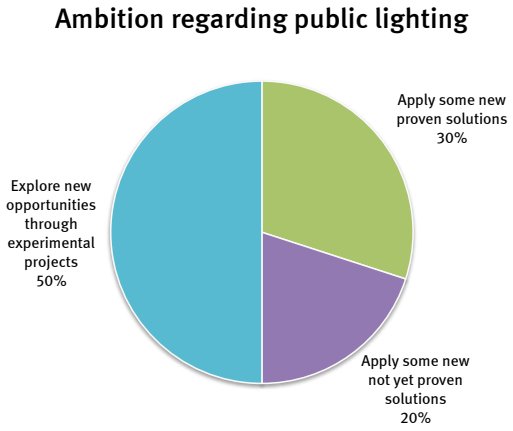


Figure 26 - Ambitions regarding public lighting

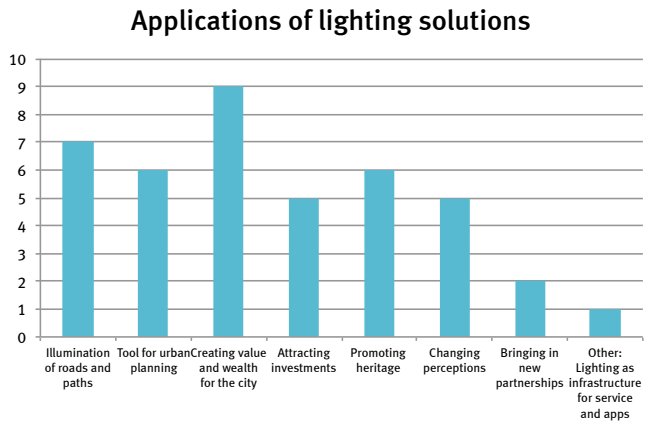


Figure 27 - Valuable applications of innovative lighting solutions

The participants were asked to name the main societal challenges in their city in order of importance, in free text format.

One city did not answer this question.

1 2 3

The answers on number 1 were:

- Public safety
- Revitalisation of the old town from tourism and landscape viewpoint
- Very rapid growth
- Safety
- Improving quality of life
- Infrastructure
- Modernisation of the city, since almost the whole city was build with industrial and experimental methods in the 60's. Therefore a major program of modernisation is necessary
- Relatively low living standard
- Employment
- Housing shortage

The answers on number 2 were:

- Decrease vandalism
- Containment of the energy use and lighting pollution
- Answering to users needs
- Vandalism
- Influence of citizens on quality of life by lighting
- improving investments possibilities
- Need for revitalisation of the industrial areas. The vision is to shape the areas to meet green growth and to be a photonics cluster in the greater capitol
- Insecurity
- Safety and security
- Segregation

The answers on number 3 were:

- Preserve the buildings architecture
- Re-qualification of suburban areas (incl. safety viewpoint)
- Financially harder economy
- Maintenance
- Mobility
- Urban forestry/ landscaping
- The demographic challenge, with unemployment among young people and an ageing population, but without a direct match in qualifications, and with a higher need for welfare services
- Environmental awareness
- Community/public spirit
- Unemployed

Subsequently the participants were asked to indicate to what extend the societal needs in their city can be alleviated by innovative public lighting solutions by selecting the appropriate response from:

- Yes, significantly
- Yes, somewhat
- No
- I don't know

The results are shown in Figure 28.

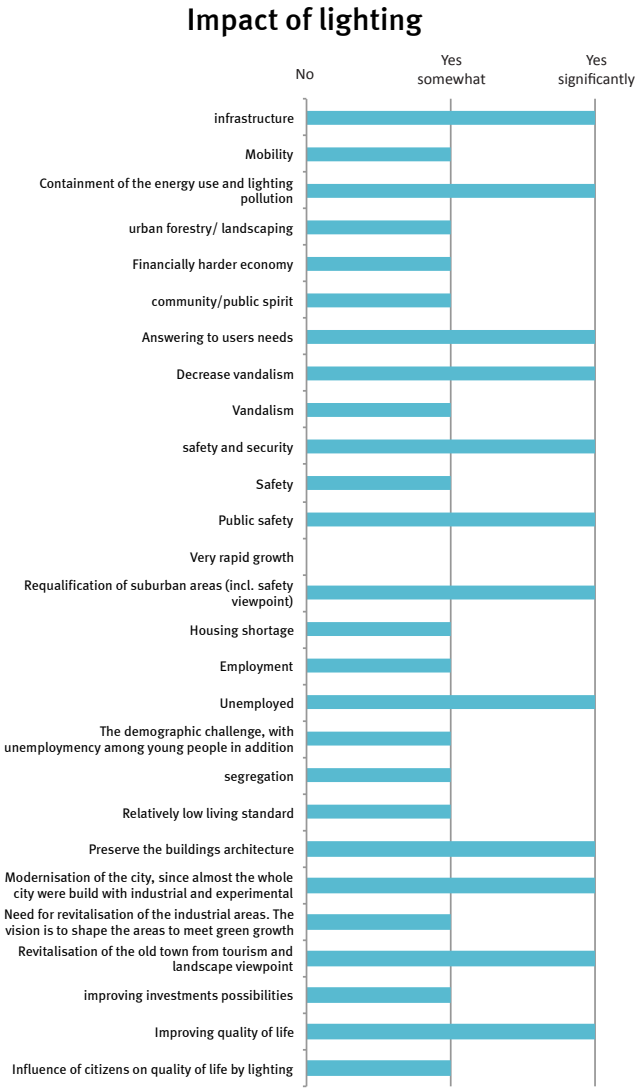


Figure 28 - Impact of innovative lighting solutions on the alleviation of the societal needs in the city

The participants were asked to name the most important quality issues for maintenance in their municipality, in free text format.

Six cities did not answer this question.

1

The answers on number 1 were:

- Safety and vandalism
- Energy saving
- Economy
- Lighting - quality and design
- Reliability of the lighting system
- Value for money

2

The answers on number 2 were:

- Economical maintenance
- Safety
- Competence of maintenance
- Long term investment with low maintenance
- Quick response at failures
- Safe and beautiful

3

The answers on number 3 were:

- Sustainability of installed products
- Quality of lighting
- Quality of equipment
- Energy efficiency
- Uniformity of illumination

The participants were asked to name the project that they consider a 'best practice' when it comes to public urban lighting, in free text format.

Six respondents answered the question:

- Kanalens ljus, Malmö 2005
- PLUS Interreg IVc: Lyon, public parks and events, and Leipzig, old town and events
- Under Kristallen square, Copenhagen centrum (about 250m south of Black Diamond Library)
- Stavanger cathedral, Stavanger
- Light-S, Eindhoven, Strijp-S
- Fx. Nykredit - open space, Kalvebod Brygge, Copenhagen

Selection of ‘best practices’

From the results of the survey two cities were selected as interesting for further research into state-of-the art in procurement of urban public lighting.

A G

Albertslund:

- Only city that defined ecological effectiveness as the starting point for the main driver (sustainability) of the project
- Only city that indicated as need to create new industry and public-private-research partnerships in the city and to establish a green lab and to create a long-term vision to be front-runner for sustainable lighting and smart city solutions
- Only city that indicated that in the project evaluation was tested if the needs were met (in stead of according to specification)
- One of the two cities that purchased an innovative lighting solution requiring research and development
- Only city that indicated to use OPI as the procurement procedure and award criteria
- One of the cities that indicated to have the ambition to explore new opportunities through experimental projects

Gothenburg:

- Only city that procured a smart system
- Only city that involved external stakeholders in the needs definition
- One of the two cities that included experience in the type of solution that was purchased
- Only city that defined quality of life as the starting point for the main driver (sustainability) of the project
- Only city that indicated that demolish and recycle were included in the offer

Best Practices - Interview results

With the two ‘best practice’ cities interviews were held and earlier reports were used to make rich descriptions of the best practices.

Albertslund

Albertslund Kommune

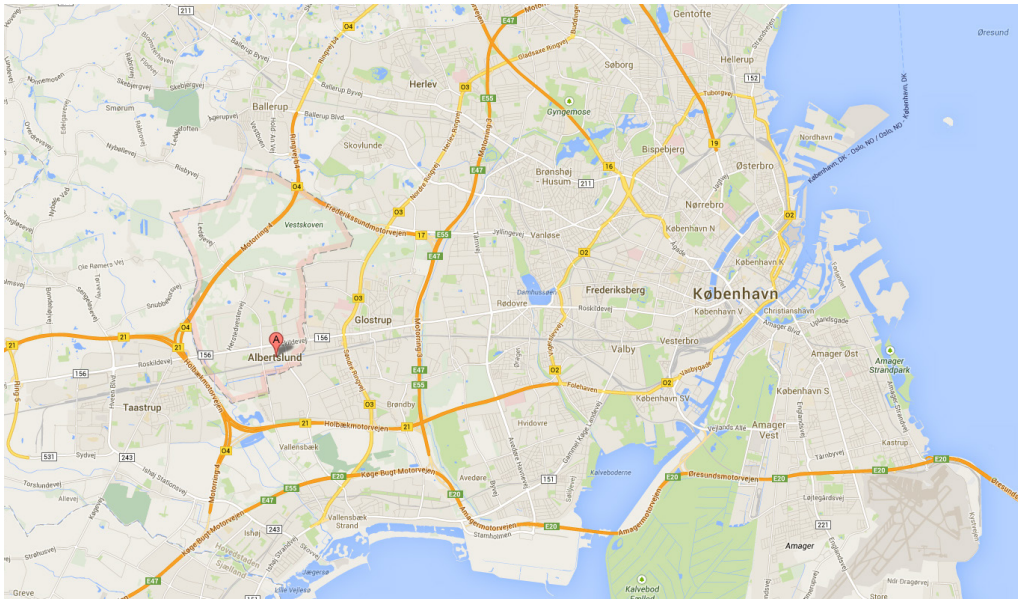
Municipality of Albertslund lies 17 km west of Copenhagen. It has a population of nearly 28.000 inhabitants. The town bustles with activity and has a history of good cooperation with its citizens and businesses. Albertslund experienced a steep growth in the 1960's, but it's outstanding city planning resulted in a city that is still vibrant. Most houses are one to two-storeys and host young families. Most of its street lighting also dates back from the sixties and is worn out.

Since 1993, Albertslund local authority has been preparing a Green Accounting Statement showing the consumption of heat, electricity and water, production of waste and CO2 emissions. The objective is to reduce energy consumption and improve the environment.

Albertslund is undergoing a renewal process, which is also mirrored in "Master Plan South", the largest housing renovation project in Danish history. Rental housing in Albertslund South is being renovated these years, creating the framework for the good life in town. Over the next ten years half of the town residents will have their homes renovated. The street lighting will be upgraded towards smart city systems as well.

Some numbers:

- Area: 23 km2
- Population: 27.706
- 61% of housing in Albertslund is rental-housing, while 34% is privately owned.
- Appr. 10.000 light points for street lighting



Images of Albertslund - photo credit Jeppe Carlsen

Images of Albertslund - photo credit Bruno Agerholm

The municipality of Albertslund has adopted a new lighting plan which is solely based on LED technology. The plan includes the development and testing of different street lighting designs and Wi-Fi based smart control systems.

In recent years, the town has contributed to the invention of several outdoor lamps, in close cooperation with designers, manufacturers and universities; noteworthy is the award winning “A-lamp”.

Today, the first stage of a “Scandinavian Lighting and Photonics Science Park” is under development in Albertslund, with the ‘Danish Outdoor Lighting Lab’ (DOLL) as the driving force.

The Alberslund lamp - designed in 1963

The A-lamp - designed in 2009 = photo credit Jeppe Carlsen

The Danish Outdoor Lighting Lab (DOLL) - A Photonics Green Lab

Albertslund Kommune

Danish Outdoor Lighting Lab (DOLL)

DOLL is a platform for the development of energy efficient outdoor lighting. It is Denmark's new platform for the development of tomorrow's LED lighting. DOLL's purpose is to create energy savings, more intelligent indoor and outdoor lighting and and increase Denmark's competitiveness on the European and global market.

DOLL consists of three laboratories :

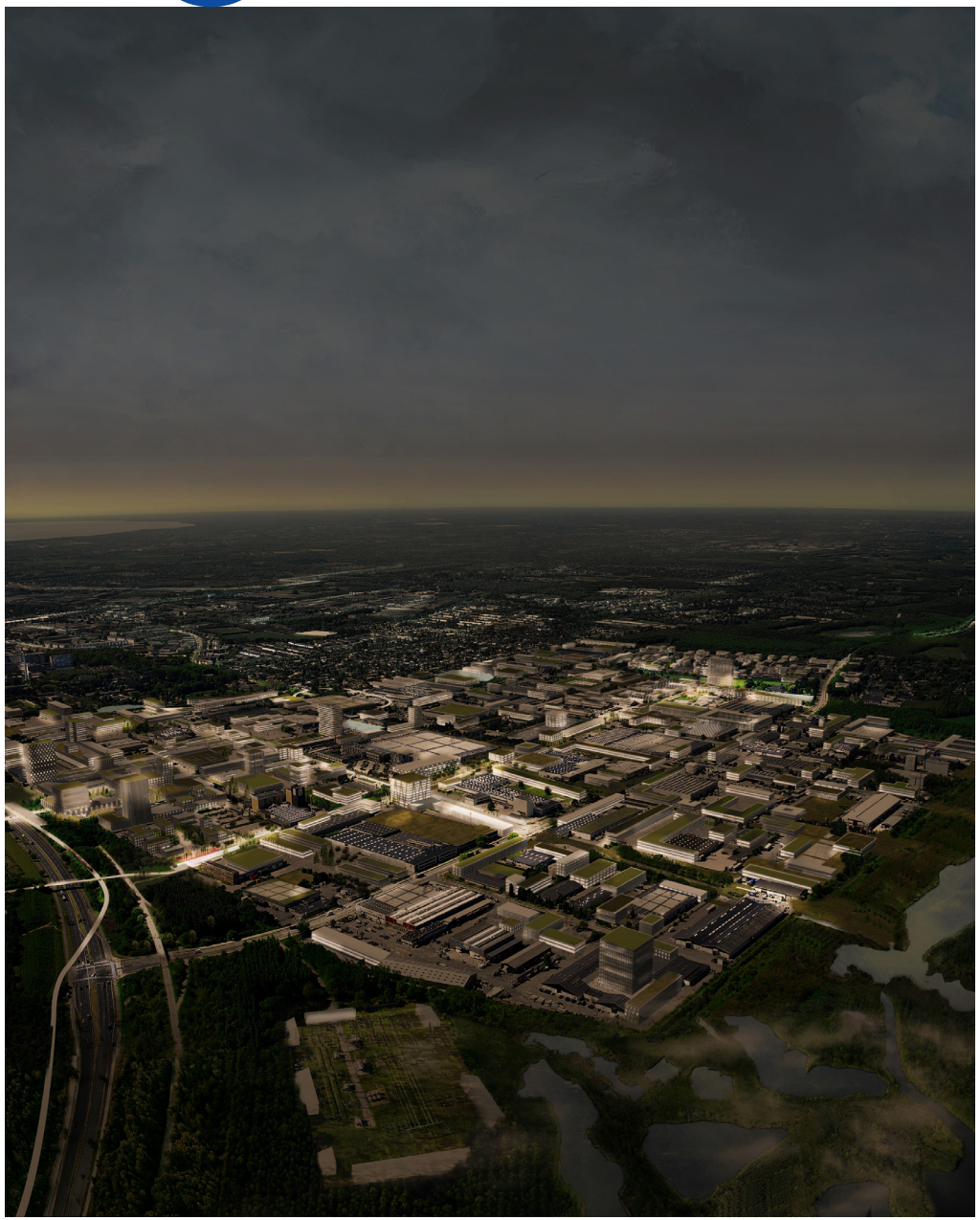
- Quality Lab at DTU Photonics in Roskilde, where manufacturers and buyers can undergo independent quality measurements.
- Virtual Lab at DTU Photonics , where lighting solutions in specific urban areas is visualized in 3D format. It allows for the involvement of decision makers and citizens on a qualified plan.
- Living Lab in Hersted Industrial Park in Albertslund, where lighting, control systems and smart city technologies will be tested in scale 1:1.

In DOLL's Living Lab, producers and buyers set up and test outdoor lighting in scale 1:1. Living Lab is aimed at companies that work with lighting, intelligent management and Smart City solutions. Municipalities and regions will then have the opportunity to experience different solutions in a natural urban environment. This gives decision makers a better basis for deciding on the purchase of new fixtures.

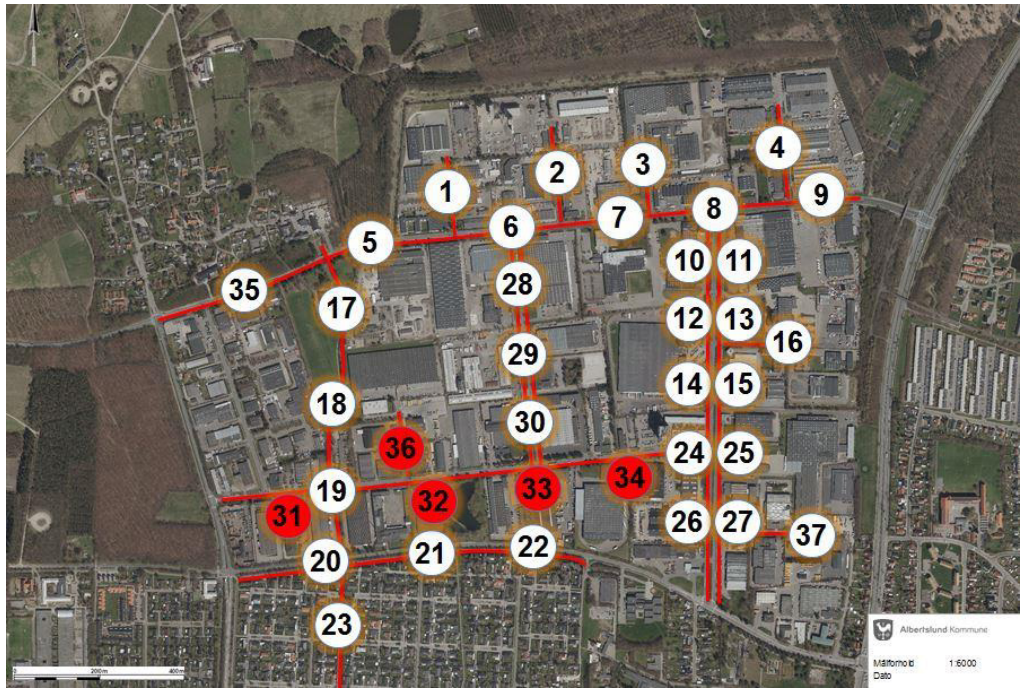
The use of the three labs in combination gives a new dimension to the use of test as part of public tenders.

Streetlighting in Albertslund - photo credit Shutterstock

Quality Lab at DTU Photonics - photo credit Loa Brix



Hersted Industrial Park by night - visualization credit SLETH Architects



The outdoor area is divided in smaller test fields (49 different parcels), and the municipality works with many companies to develop new smart lighting solutions. The equipment is bough with subsidies from national government, and is rented back to the companies for 10 years as part of the living lab. Companies are allowed to make changes and install new types (as long as they respect the urban lighting regulations). In this way the area has been transformed into a show room of the latest technology. Visitors from all over the world visit the area and the city is invited frequently to take part in international networks, which enables them to play a role at top level.

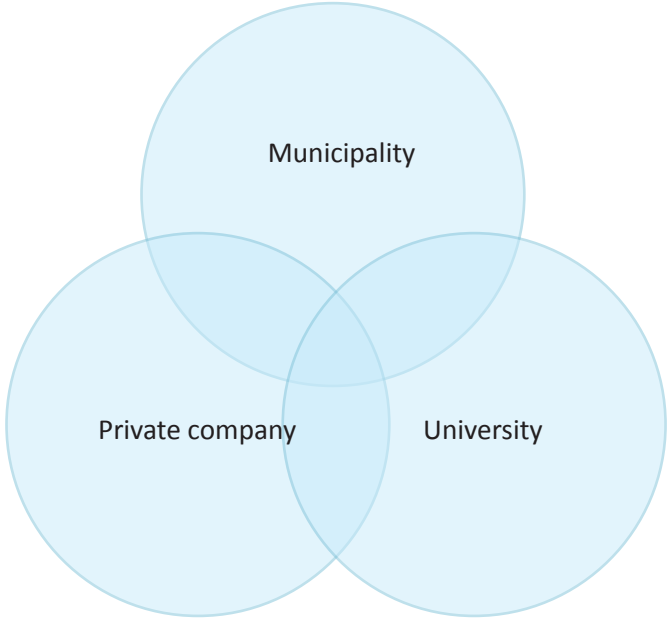
Innovation Hub

Albertslund has become an incubation hub for start up companies and spurs innovation by asking the right questions to the industry. For this purpose it has set up a city knowledge program, to ensure technology is used to transform the city and create new jobs. It works through a triple-helix organisation: Gate 21.

The organisation makes projects addressing public demands in a sustainable development and for green growth. The focus areas are:

- energy and resources
- transport
- city and construction

Gate 21 works in a triple helix model.



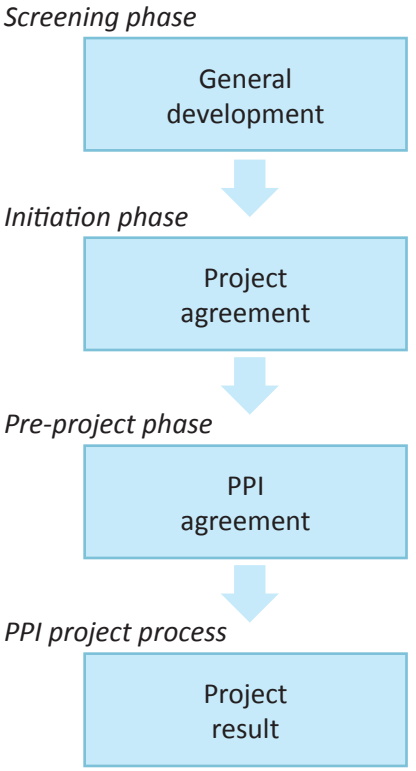
Procurement process

Albertslund uses the possibility the EU procurement guidelines offers for innovation projects. When innovation in a public-private partnership is taking place, no open tendering process it needed. This Public-Private Innovation (PPI) is now a standard procedure in Albertslund. The city uses its budget for renewal and maintenance for innovation projects with industry.

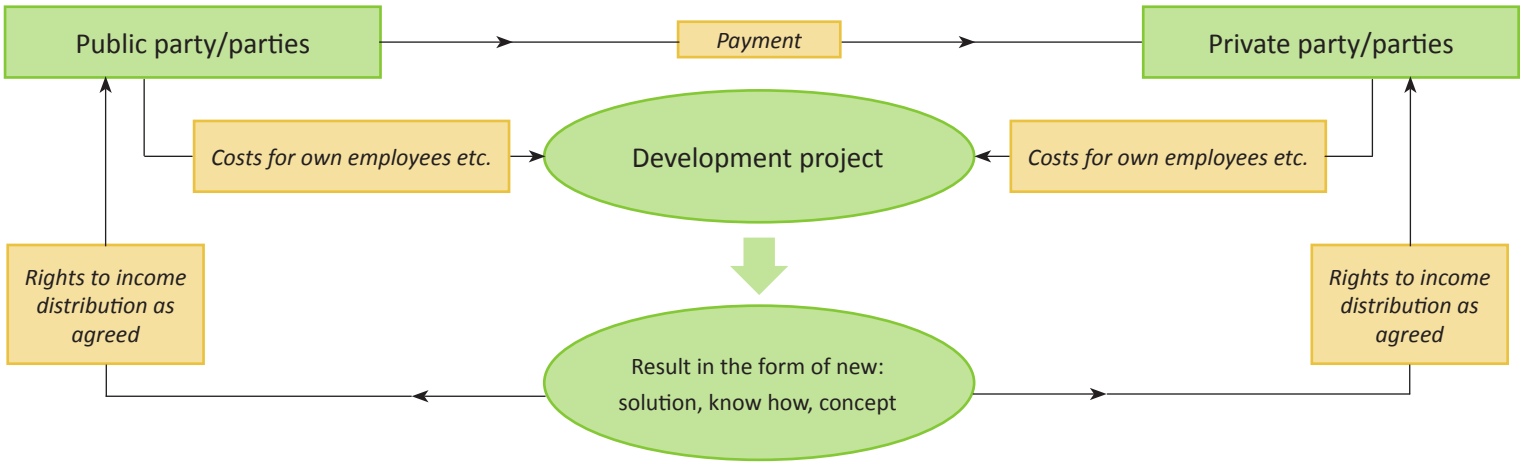
In the PPI model, a development can be organized so that the actual development procedure can take place without tendering. The model implies the preparation of a preliminary contract (project agreement) between the partners already from the initiation of the project. The project agreement deals with the anticipated benefits of each partner and the initial agreements on the commissioning of the project. Once the project has taken a little more shape, a PPI agreement is made in which the parties mutually agree on the division of the results obtained in the project, such as profit, rights and knowledge.

The PPI model consists of the following elements:

- A note containing a description of the elements of the model and an explanation of the legal aspects in the model.
- A handbook that guides the parties through the model step by step.
- Standard document for OPI Agreement.



The Public-Private Innovation (PPI) model



Model for PPI development projects

Gothenburg

City of Gothenburg

The municipality of Gothenburg is the second largest city in Sweden, situated by the Kattegat, on the west coast of Sweden The city proper has a population of 533.260, with 549.839 in the urban area and about one million inhabitants in the metropolitan area. The city was ranked as the 12th most inventive city in the world by Forbes (2013).

Gothenburg is home to many students, as the city includes both the University of Gothenburg and Chalmers University of Technology. Volvo was founded in Gothenburg in 1927. The city is a major center in Sweden for sports and is known for hosting some of the largest annual events in Scandinavia. The Gothenburg International Film Festival, held in January since 1979, is the leading film festival in Scandinavia with over 155.000 visitors annually. During the summer a broad variety of music festivals take place.

The city of Gothenburg has 95.000 luminaires spread over the city and is since 1975 responsible for asset and maintenance. Since that time, Gothenburg is introducing an open lighting solution. Together with Oslo Gothenburg participated in a European project for a test pilot in 2007. Ever since the city introduces intelligent systems in small badges throughout the city. The main goal for introducing intelligence and LED is energy saving (most of the replacements is replacing Mercury lamps with LED). The municipality planned to finish the replacement this year, but will still have to replace another 1 – 2.000 luminaires. within next year's budget.

Götaplatsen

Smart lighting systems

The municipality of Gothenburg deliberately chooses for projects in small badges and for different lighting systems at the same time, to stay independent from suppliers. At this moment the city has 3 different smart lighting systems in use. All systems are based on real time information, have an updated management and cause information, where all information is stored in one place, enable the control of individual armatures, for instance turning on/off lights, ability to dim one or more lights, and finally have adaptive control and situational adjustments, e.g. unguarded crosswalks, walking passages, etcetera.

- The first system is a power line system. It is a dynamic system, making use of preset scenario's, based on time tables. This is used in the 'Gamlestadsvägen' lighting project, and will be introduced later.
- The second system is a wireless system: luman radio. This is an interactive system. It is placed in the main square in the city center (Götaplatsen), where the music hall, concert hall and theater are situated. These lights can be controlled or switched off entirely, adjusting the time ad activity in the square. It can also adjust to the music system and take part of the entertainment of the happening at the moment.
- The third is the city touch system, an intelligent lichtmanagement system, which is currently being tested in a small area.

Gamlestadsvägen

Färgfabriksgatan

The ‘‘Gamlestadsvägen’ project

The gammle stad varen is a residential area for social housing, close to an outlet area. There is no business after shopping hours (shops close at 18.00) and good street lighting is important for social security reasons.

The project started in 2011, consisted of 125 luminaires that were replaced by LED lighting, being the first big LED project in the city of Gothenburg. Up till then LED did not stand up to the quality standards and was too expensive, by this time it was priced.

It was also the first project consisting of a smart system with LED. The lighting is dynamic, following a time table. Applying light scenes differing over evening and night, according to the traffic and number of people in the road.

The main reason to start The ‘Gamlestadsvägen’ lighting project was sustainability. The municipality wanted to save on energy by controlling and adjusting the lights. This system would also reduce maintenance costs. In Sweden all maintenance is owned by contractors; cables are owned by the municipality.

A recent project now involves a large project for bicycle and walking paths. An important goal in the city it to improve bicycle roads and reduce car use; therefore the luminaires on these roads need to be improved.

Procurement process

The Open Procedure Tender is the standard way of working for the municipality of Gothenburg. The tender can consist of small projects, for instance on a pilot area for testing, or larger projects, such as parts of the city.

It is not easy to specify a tender in a way that does not lock in one company. That challenge is overcome by specifying the needs, such as being able to dim, the information that needs to be available, whether through radio/air or through cable, the type of control, including the number of operating years and maintenance. The city provides in this way the needs, defined in functional requirements, i.e. luminaires have to be controlled independently, the functionality of the control in the luminaire, the use of existing cables. Next to the technical specifications stand the guidelines and regulations. Early in the projects the city includes different suppliers. For instance in the PCP process on the bicycle paths 10 different companies were asked to deliver luminaires. During the project it was reduced down to 3 companies. This PCP will be ended by the end of March 2014.

Learning example for others

The Open Procedure Tender (OPT) is also used for better learning of the procedures. Gothenburg is the second largest city in Sweden and lots of other cities turn to the municipality for advice. Many other cities have no engineers at work within the municipality, therefore Gothenburg takes the lead to make it easier for others to follow.

The main learning is to include testing in the procurement process. Gothenburg defined a Factory Acceptance Test and an Operating Acceptance Test. These are good to rely on before installation, for they provide an early notice when things don't work. Also the way to perform these tests is included in the procedure, under the condition that suppliers don't get the money if they do not perform the tests.

Gothenborg participated the European funded project Esoli. Here the city also defined learnings that are relevant for PCP in smart lighting systems:

- Visit other end users who have installed ISL to find out more information and get their experience and knowledge.
- Ask if you can take active part in others tenders
- The EUQ is a guide for questions to ask and information to get before buying
- Divide the tender into two parts instead of a turnkey contract. It will be more economical. One part for the system and software and one part for the installation.
- As the owner of the system it is important to be present on site and take much responsibility when buying ISL.
- Be aware of the functional requirements both for the whole installation and the parts of the system. Be sure that the interface allows communication to your own database and also is able to broadcast the information to the suppliers.
- The system should be open so you are able to change suppliers in the future (EU directive)
- The software should be owned by the end user so you still have it in your custody if the supplier is sold or goes into bankruptcy.
- Designing for visibility rather than trying to obtain a certain light level will reduce the amount of energy used and will increase the effect on safety and security as well as improve the civilians satisfaction level when it comes to social safety.
- Pavement reflection of roads should always be taken into account. User perception and accident history are other information sources that might lead to energy reduction.

[Best Practice Catalogue of the ESOLi project, available through www.esoli.org]

Advice to other cities procuring innovative lighting systems

In future smart systems will increase. Different types of intelligent systems in traffic and city will be integrated where intelligent lighting will be a part. Expended requirements to meet the new opportunities should already be in the control center. The advice that Gothenborg provides to other cities in this situation is:

- Start with a small project, maybe 200 – 300 luminaires.
- Learn from other cities: there are lots of documents available, for instance from European projects, where first mistakes are evaluated. We can learn a lot from each other.
- If you do not have the knowledge within your municipality, then include a good consultant. It is not about lighting alone anymore, the whole IT-part is new, it is also about communication and information now. If you do not have any experience, ask for help.
- Realise that the first smart project is going to cost a little extra, for everything is new and mistakes will be made. But you will learn a lot!

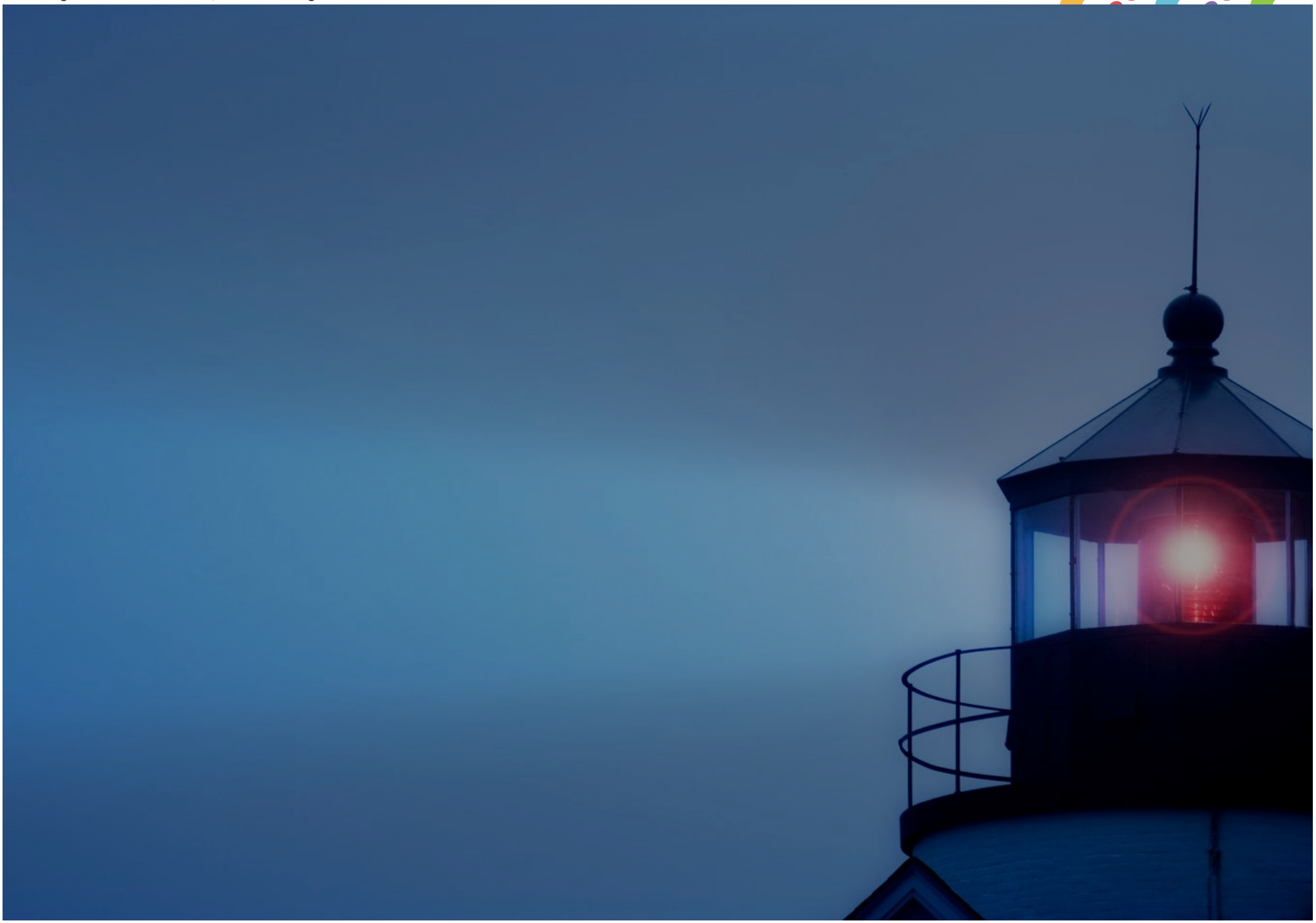
Conclusion

The objective of this research was to establish the state-of-the-art in urban public lighting. For this purpose the five ENIGMA partner cities presented their current way of working and a recent pilot project, an online survey was held, and three cities were interviewed as a best practice.

Overall the conclusion is that smart lighting systems are not yet applied at larger scales. LED is commonly purchased for new projects, but adaptive lighting is still not wide-spread. Most of the cities are still in the pilot phase for smarter lighting solutions, often enabled by European projects. The experience is still limited, but overall it seems to be more complex than anticipated. This complexity is due to:

- The required ICT knowledge, which is not commonly available within municipalities
- The required cross-departmental collaboration that is needed in municipalities for smart solutions (e.g. including traffic management)
- Solutions should be context specific, creating more diversity in applied solutions and required testing procedures
- The lack of standardisation and open systems that allow easy integration of solutions from different suppliers

Despite the complexity the cities believe that the developments towards smart city solutions are important and necessary, and provide new opportunities.



About the TU/e Intelligent Lighting Institute

The TU/e Intelligent Lighting Institute (ILI) was established in 2010 to investigate novel intelligent lighting solutions that will become within our reach by the large-scale introduction of LED technology, with a special emphasis on how these new solutions might affect people. We do this in collaboration with departments of the TU/e and partners in the public and private sectors. The lighting research performed at ILI is producing unique know-how and a technological head start for the participating parties, the Brainport Region, and as part of Europe.

Research

ILI's mission is to search for revolutionary lighting solutions. It does this using an interdisciplinary approach that takes society as its laboratory. Well-being and sustainability are given top priority in all facets of its research and resonate throughout all of the strategic programs.

Five lines of research

The lines of lighting research at ILI have been created to address concrete issues faced by society. This approach is also known as 'design for need'. The institutes research programs tackle practical matters:

- The Brilliant Streets research program aims at future outdoor lighting systems
- Researchers in the Sound Lighting program explore other applications of light that could be beneficial to health and well-being
- Computational methods for illumination optics and rendering of light patterns
- If researchers in the No Switches Allowed program get their way, radical change is on the way
- The Open Light program explores all of the possibilities of a particular technology, without any preconceived application ideas

Brilliant Streets

The Brilliant Streets research program aims at future outdoor lighting systems. Outdoor lighting is there to enhance traffic safety and to increase feelings of comfort and safety for people on the street. This goal remains, but opportunities for advanced applications are plenty because of technological advantages: new lighting technology (LED), advanced sensing, wireless communication and embedded processing.

These new technologies make interactive systems possible, and allow for precise control of lighting. It is, however, not known how people experience adaptive lighting and what this brings about emotionally. The challenge is to use technological advances to improve user experience while minimizing energy use. Brilliant Streets regards outdoor lighting systems and one of the subsystems of a Smart City. Sensing and communication capabilities will be used in the future to enhance city services.

LightHouse

The ENIGMA project is carried out by LightHouse, the solution partner of ILI. LightHouse aims to disclose the knowledge of the ILI research programs for society. This is realised by applying the knowledge, methods and designs in intelligent lighting solutions through concrete projects for external organisations.

dr.ir. Elke den Ouden

Program manager Brilliant Streets & Strategic director LightHouse

e.d.ouden@tue.nl

dr.ir. Rianne Valkenburg

Value producer LightHouse

a.c.valkenburg@tue.nl

For more information:

www.tue.nl/ili

www.ili-lighthouse.nl

www.facebook.com/ililighthouse

This report presents the results of the research into the state-of-the-art in urban public lighting carried out as part of the ENIGMA FP7 Pre-Commercial Procurement project (Work package 1, task 1.1). The research was done by the Intelligent Lighting Institute of the Eindhoven University of Technology, partner in the ENIGMA project.

This task involved three steps. First of all the partner cities presented their current way of working and a recent pilot project. Secondly, an online survey was held among the members of Eurocities and LUCI, partners in the ENIGMA project, to gain insight in the state-of-the-art in urban lighting infrastructure as well as in the applied procurement processes. With the results of the survey, two best practices were selected and interviews were held to review the way the solution was specified in the call and how the value of the solution was defined and evaluated. The results will be used as a baseline, to ensure that the joint procurement process for public lighting that will be executed in ENIGMA is indeed innovative.

For more information on the ENIGMA project, please visit: www.enigma-project.eu

Eindhoven, 31 March 2014