ENIGMA

Requirements Smart Lighting Solutions

Research results WP1.6 - 28 March 2014

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Disclaimer: This report presents the views of the authors, and do not necessarily reflect the official European Commission's view on the subject.

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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.

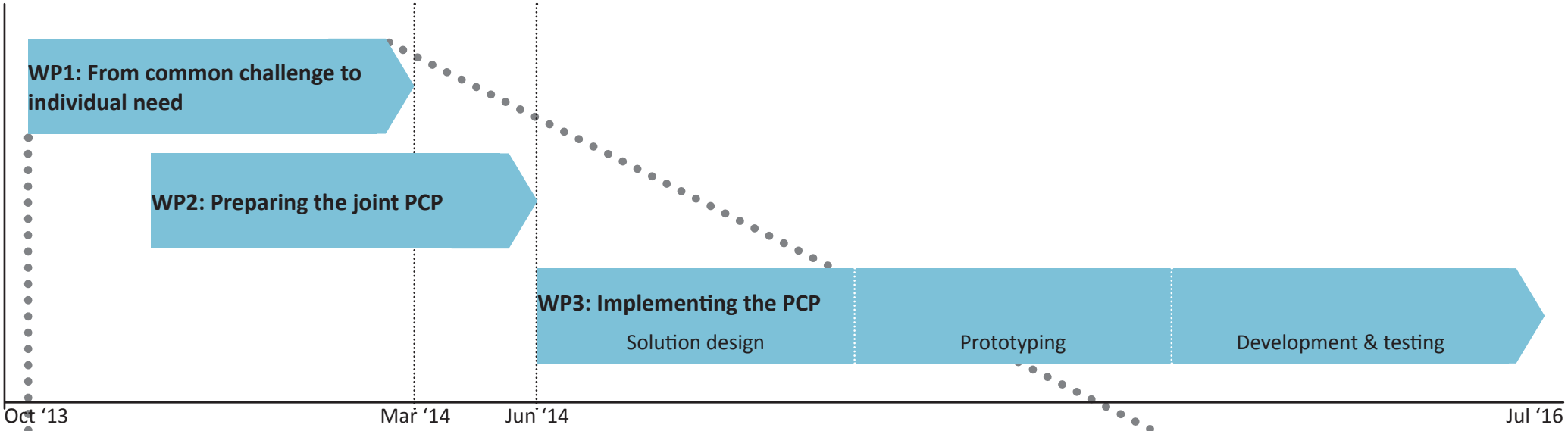
Malmö
Malmö is Sweden's third largest city and the commercial centre of southern Sweden. The municipality has had a strong focus on creating a safe, attractive and environmentally aware city, a city where the citizens feel safe using public areas. The last decade has seen Malmö consciously reinventing 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.

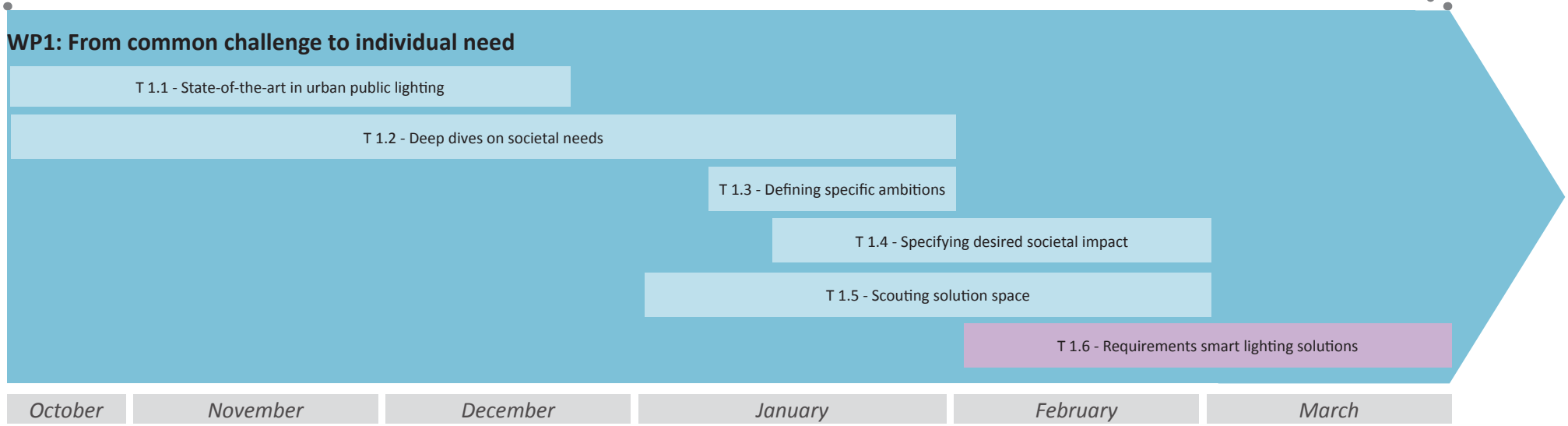
Stavanger
Located on the South West coast of Norway, the City of Stavanger and its 130.000 inhabitants represent the country's most densely populated municipality. Stavanger is the 4th largest city in Norway, known as the "Oil Capitol" since the oil industry is located here. The local authority has focus 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.

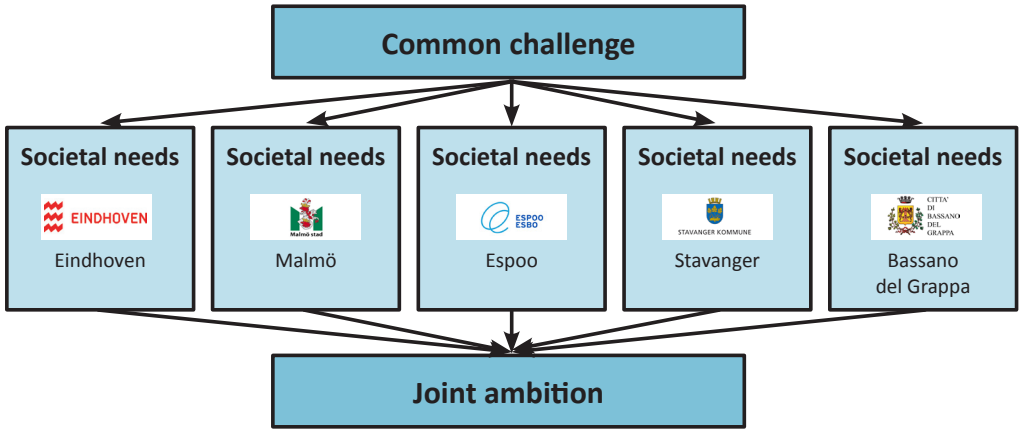
Work package 1 provides input for the preparation of the joint PCP.

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.

Requirements & assessment criteria

This report presents the outcomes of the Task 1.6 in the ENIGMA project. The initial trigger for PCP is a need that the procurer wants to be solved and there are no solutions for that available on the market at the moment. In ENIGMA, the needs of the procurers, i.e., the cities (Bassano del Grappa, Eindhoven, Espoo, Malmö, Stavanger) have been identified earlier in the work package (WP) 1.

The societal needs of the cities in general and the needs in the specific pilot areas within the cities have been round up in Task 1.2 (Deep dives on societal needs). The needs have been identified in Task 1.3, and the desired societal impacts have been reported in Task 1.4. These identified needs are used as inputs for the functional requirements and a proposal for assessment criteria for the tender in Task 1.6. Tasks 1.1 and 1.5 provide information on the state-of-the-art and the current and near-future solutions in public lighting. These pieces of information are used as inputs in Task 1.6.

From desired societal impact to functional requirements

The functional requirements have been identified on the basis of the desired societal impacts (den Ouden, Valkenburg, Tähkämö, Halonen 2014). The needs of the cities were developed into two main themes: a vibrant city and a sustainable city (please refer to the report of WP1.4 for the detailed description). The ambitions are:

A vibrant city

A vibrant city that is enjoyable to live in with all the activities, facilities and urban environment and where economic situation is good if not thriving.

- **Active & healthy citizens**
- **Good economic climate**
- **Strong social networks**

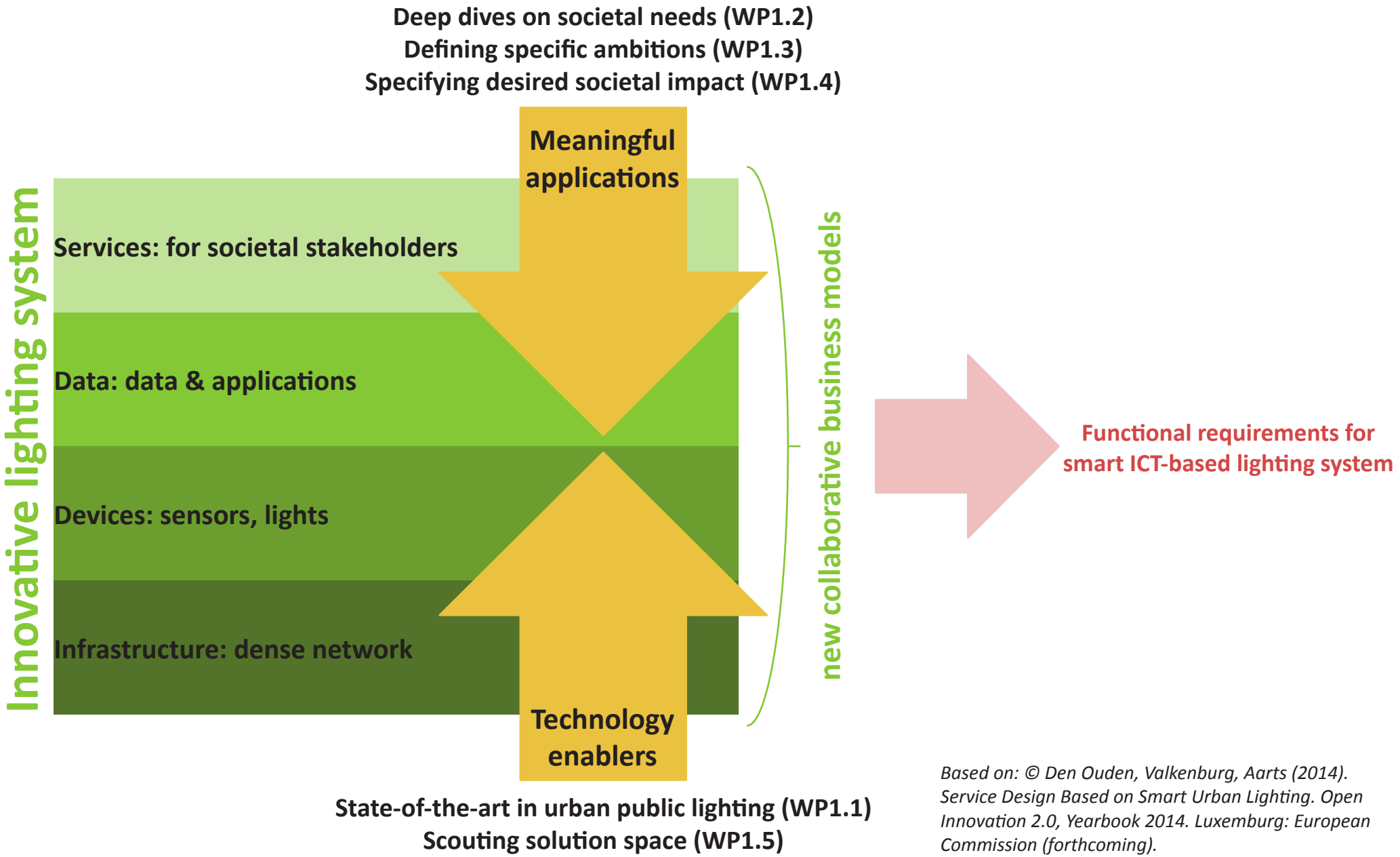
A sustainable city

A sustainable city where the environment is respected and preserved without compromising the quality of life of the citizens and the economic climate.

- **Social wealth**
- **Caring for the environment**
- **Sustainable economy**

Furthermore the functional requirements are build upon the report 'scouting solution space' (Schreuder, Ambrosiussen, Erkamp, Hogema, Nauta, 2014). The report provides an overview of the transition of an industry focussing on lighting products to ultimately smart city services (please refer to the report of WP1.5 for the detailed description).

The functional requirements presented in this report are based on the earlier WP 1 reports and the inputs partners provided in the workshop 15 January 2014 in Stavanger (provided in Appendix). The inputs directly from the partners were collected to comprehend their views on the smart ICT-based lighting solution that will be implemented within the ENIGMA project.



Based on: © Den Ouden, Valkenburg, Aarts (2014). Service Design Based on Smart Urban Lighting. Open Innovation 2.0, Yearbook 2014. Luxemburg: European Commission (forthcoming).

Towards smart city services

The common challenge for ENIGMA partner cities is 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.

The ENIGMA partner cities have defined common societal needs related to smart lighting. As an example, several extracts of the ENIGMA report "Specifying Desired Societal Impact" show what needs should be addressed.

- *"the right light at the right place";*
- *"people becoming aware of all the things the city has to offer";*
- *"providing an inviting atmosphere for people to be and meet each other";*
- *"encouraging people to spend time outside and take care of their nearby environment together";*
- *"providing an enjoyable outdoor environment people are encouraged to spend time outside and take care of their nearby environment together; encourage sustainable behaviour".*

Addressing these needs is vital for becoming vibrant and sustainable cities, which is a path towards becoming Smart Cities.

Fulfilling these needs requires a step change in smart ICT based lighting systems. Innovative lighting solutions integrate services, ICT data applications, devices and/or infrastructure towards meaningful applications that contribute to desired societal impact.

Large-scale applications of smart city solutions are still very limited in number. This is caused by difficulties in integrating solutions (e.g. proprietary protocols), focus on cost instead of value, difficulties in developing appropriate business models, and a focus on quantity of light instead of quality of light.

With ENIGMA, the ENIGMA partner cities want to achieve a breakthrough in development towards smart city solutions through a joint Pre-Commercial Procurement (PCP). The ENIGMA project will be able to make a first step using smart ICT-based lighting systems to develop meaningful applications to address the partner cities' societal needs.

Smart ICT-based lighting systems

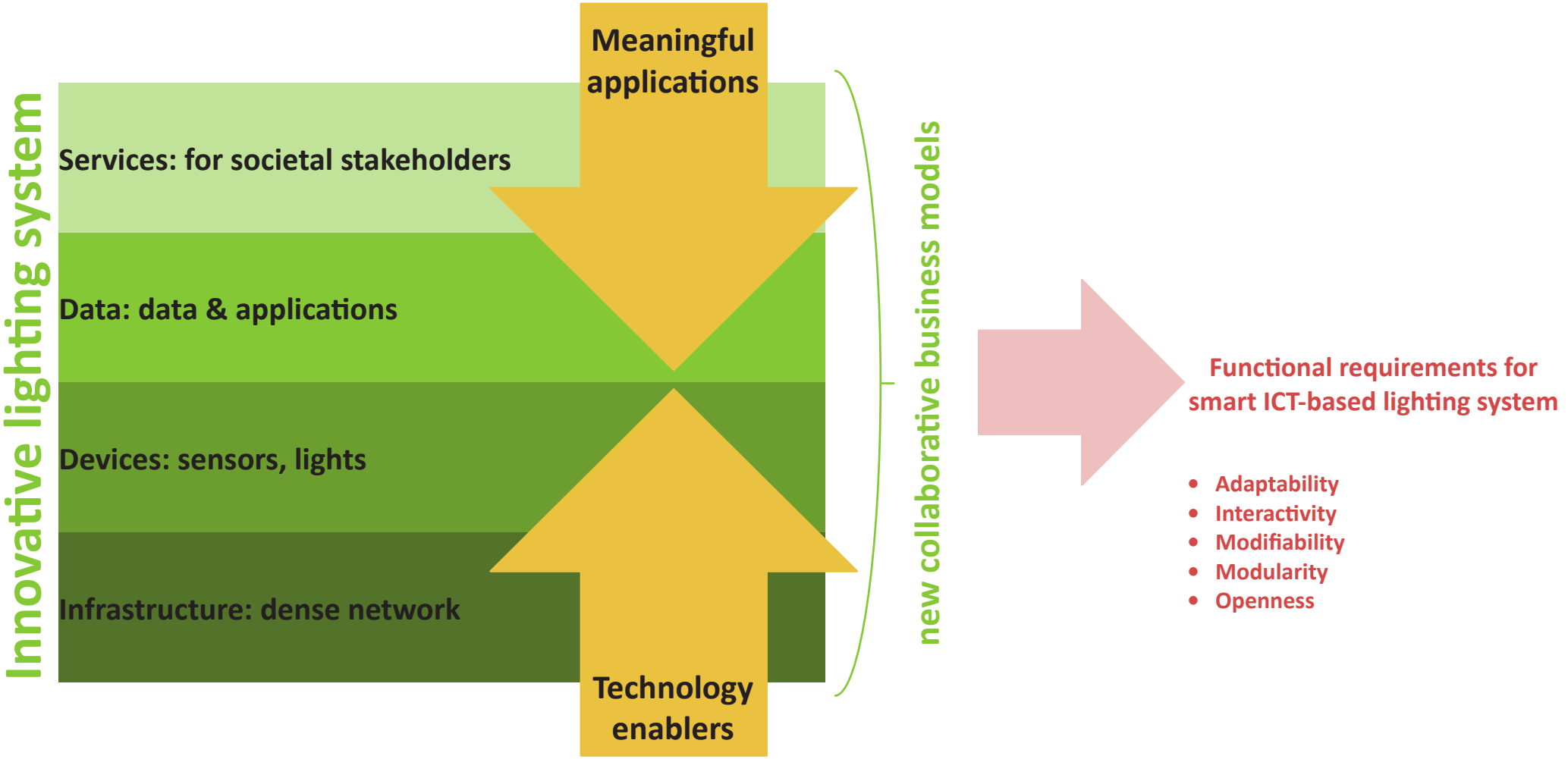
The transition from regular lighting systems to smart ICT-based lighting systems requires adaptation of all four layers of the model on the previous page:

- On the infrastructural level ICT networks need to be added to the power networks that are already in use for lighting. This can be either wired and wireless communication networks.
- On the devices level new modules will be needed to add local intelligence to the system. Next to the light sources, controls and luminaires also different types of sensors and communication interfaces are needed.
- The data level is already a new level for innovative lighting solutions, that is specifically adding ICT aspects, such as data and (software) applications
- The services level can only be integrated in the total system when it is ICT based. The services can be of various kinds, including the more lighting related services as maintenance and asset management, but also smart city services such as enhanced mobility, energy etc.

Collaborative business models

The transition towards smart ICT-based lighting systems also requires rethinking of business models. A number of aspects need to be addressed:

- The addition of ICT-based systems to public lighting provides new business opportunities. It can be expected that value adding services will bring in revenues that enable further investments in new modules and infrastructure.
- As the total solution is not yet brought to market by a single company, it is to be expected that a consortium of various companies is needed to provide a smart ICT-based lighting system. Within the consortium new business models are needed to ensure a sustainable business for all parties involved.
- The solution needs to provide a sound business case for the short and longer term. Not only for the companies that bring the system to market, but also for the cities that will want to adapt the system to future needs and upcoming technologies.


Innovative lighting system
Services: for societal stakeholders
Data: data & applications
Devices: sensors, lights
Infrastructure: dense network
Meaningful applications
Technology enablers
new collaborative business models
Functional requirements for smart ICT-based lighting system
Adaptability
Interactivity
Modifiability
Modularity
Openness

Functional requirements

Five functional requirements are identified so that the smart ICT-based lighting system is able to fulfil the needs of the cities and pilot areas, and allows the transition from lighting products to smart city services.

Adaptability

The smart ICT-based lighting system needs to be adaptable in order to enable changing the lighting settings according to the varying needs of diverse users and contexts.

Interactivity

The smart ICT-based lighting system needs to be interactive in order to enable the people to control and “play” with the light.

Modifiability

The smart ICT-based lighting system needs to be modifiable in order to upgrade or extend the system if needed to make it future-proof.

Modularity

The smart ICT-based lighting system needs to be modular in order to fit the design of the installation to specific needs and to facilitate the maintenance of the system.

Openness

The smart ICT-based lighting system needs to be open in order to connect it to other systems and to enable other systems to connect with the lighting system.

The functional requirements are not supposed to be very detailed or technology-specific but “open” enough to enable the consideration of the particular needs of the pilot areas and the possibilities of several technologies.

Adaptability

The smart ICT-based lighting system needs to be adaptable so that it can adapt to different situations. The colour, the luminous flux and the luminous intensity distribution curve of the light source need to adapt to the varying needs of diverse users and contexts.

The lighting may need to adapt to the presence and the amount of people in the area, to the preset time schedules, to the tasks and activities in the area, and to the season and the weather. The system provides the right light at the right time for specific activities.

Adaptability enables setting different lighting settings and to change the scene according to the use of the area at a specific time. The same solution is versatile enough to enable stargazing, walking safely, meeting people (e.g. facial recognition), or guide people into certain directions.

Adaptability also enables the preservation of nature, wild life and dark sky as well as the reduction of light pollution.

Interactivity

The smart ICT-based lighting system needs to be interactive so that people can use the light as a new kind of a tool. They can choose the lighting settings according to their individual preferences and the task they want to do, from relaxing walking to avoiding injuries on a run.

The citizens can use the lighting as a tool to communicate with others and to play with. The interaction interfaces can be versatile: from smart phones and their apps to buttons, automatic sensors, detection of gestures and motion, and even mood.

The lighting and the level of interactivity changes according to the type of activity and purpose.

Modifiability

The smart ICT-based lighting system needs to be modifiable so that it can be upgraded or extended when needed. The flexibility of the system allows easy and economic updating to make it future-proof.

The system can be extended easily if needed. New products and systems can later be introduced to the existing system without barriers.

New services can be implemented in the solution for example by programming. Thus, it is possible to widen the system/installation and to add services, such as WiFi in order to enable new functions and interactions.

Modularity

The smart ICT-based lighting system needs to be modular so that the design of the installation can be tuned to the specific needs and context of the particular city. This covers the aesthetics of the design (to fit with local architecture and context), as well as functionality (selection of functions and technologies to be included in the system).

Regarding modularity, the focus is in the standards and interfaces between the modules, allowing a wide range of interoperable 'building blocks' to suit various needs.

If the lighting system is modular, the maintenance, updating and upgrading of the solution does not require the change of the whole system but it is possible to replace only the modules in question, such as the lamp, control gear, sensor or control device. Modularity also allows the technical upgrading of the system without changing the aesthetics/appearance/design of the luminaire. It allows parts of the system to be enjoyed over a long operating life.

Also the software needs to be modular to allow the selection of software functionality in line with the needs.

Openness

The smart ICT-based lighting system needs to be open so that it can connect to other systems. Openness of the solution enables the use of the light in collaboration with sources of information from outside the system itself, such as open data on weather and traffic information and business or event advertising.

Openness also enables the connectivity of the system to other relevant systems (e.g. traffic management systems) and the development of specific software applications that can be integrated into the system.

Openness refers to the network, platform, data and knowledge, and to being open to application or service design.

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Towards assessment criteria for the evaluation of tenders

The final step in WP1.6 is to define dimensions and aspects that allow the assessment of tenders in WP3 of the ENIGMA project. This will be used to propose assessment criteria for the tender, covering:

- the desired societal impact
- functional requirements for the smart ICT-based lighting system

This step is the combined effort of Aalto, ILI, TNO, AgentschapNL and the city of Eindhoven. It builds on the results of the previous steps to create concrete input for the tender process of WP3. The result is a proposal for a set of assessment criteria that will be further developed in WP3, where market consultations will be held with industrial parties. The outcome of the expert and market consultations may lead to adaptations in the formulation of the assessment criteria. This proposed set of criteria may not necessarily be applied as such in the tender procedure, a subset may prove sufficient and weighting factors need to be added. Please refer to the ENIGMA website (www.enigma-project.eu) for the latest version.

Proposed assessment criteria

The ENIGMA partner cities have defined common societal needs related to smart ICT-based lighting systems. Addressing these needs is vital for becoming vibrant and sustainable cities, which is a path towards becoming Smart Cities.

Fulfilling these needs requires a step change in smart ICT-based lighting systems. Smart ICT-based lighting systems integrate services, ICT data applications, devices and/or infrastructure towards meaningful applications that contribute to desired societal impact.

The ENIGMA partner cities are searching for intelligent lighting systems that serve a first step in becoming vibrant & sustainable cities. Smart ICT-based lighting systems need to:

- provide a wide range of applications that contribute to desired societal impact in various city settings (as described in the report of WP1.4 Specifying Desired Societal Impact)
- be highly integrable with different current and future architectures and systems (as described in the previous chapter of this report)

In this section we define the proposed assessment criteria.

A vibrant city

Active & healthy citizens

The smart ICT-based lighting system provides the right light at the right place at the right time to enable an active and healthy lifestyle. It makes the citizens feel comfortable and safe, and invites them to spend more time outside. It informs them on activities currently going on in the city and provides easy routing and guidance to the events they like. Factors in assessing this are:

- The amount of people being active
- The diversity of people being active
- The diversity of activities
- The accessibility of activities
- The level of activeness

Good economic climate

The smart ICT-based lighting system fosters the development of the economic climate. It makes people feel welcome, visitors stay longer and return more often. It literally highlights the gems of the city. Because of the good business prospect new entrepreneurs are attracted to set up commercial activities in the city. Factors in assessing this are:

- The amount of visitors
- The amount of people enjoying city gems and activities
- The number of commercial activities and new businesses being set up

Strong social networks

The smart ICT-based lighting system supports the social fabric in the city. It provides an inviting atmosphere for people to be and meet each other. They also provide entertaining places, for people with common interests to socialize. By creating a diversity of experiences for different social groups, the smart lighting system ensures there is a place and time for everybody to meet others for a joint activity. Factors in assessing this are:

- The diversity of social groups
- The amount of new social groups
- The sense of belonging to the cities' identity

A sustainable city

Social wealth

The smart ICT-based lighting system enables social wealth. By providing an enjoyable outdoor environment people are encouraged to spend time outside and take care of their nearby environment together. The system makes parks and nature more attractive after dark. Citizens are invited to take part in social activities in natural environments. Factors in assessing this are:

- The increase in sustainable behaviour
- The increase of social responsibility

Caring for the environment

The smart ICT-based lighting system needs to be sustainable so that it allows the cities to achieve their sustainability targets. A wide notion of sustainability is applied that includes the impact of the system on the environment in the city, such as light pollution and the preservation of the (urban) environment. Factors in assessing this are:

- The usage of energy saving measures over the total life cycle
- The application of renewable and recyclable materials
- The amount light pollution

Sustainable economy

The smart ICT-based smart lighting system provides an open platform for the development of various applications and services to improve quality of life in the city. It actively seeks for business models that encourage sustainable behaviour and new sustainable business with environmentally friendly solutions. It creates a platform on which attractive, yet affordable, high quality outdoor spaces can be realised. The system creates value for various stakeholders at reasonable integral costs. Factors in assessing this are:

- The implementation of sustainable business models

Adaptability

The smart ICT-based lighting system needs to be adaptable in order to enable changing the lighting settings according to the varying needs of diverse users and contexts. It provides the right light at the right place at the right time. Factors in assessing this are:

- The variety of users
- The variety of contexts
- The number of light settings

Interactivity

The smart ICT-based lighting system needs to be interactive in order to enable the people to control and "play" with the light. Factors in assessing this are:

- The level of influence people can have on the system settings
- The variety of people with access to the system
- The number of accessible different system settings

Modifiability

The smart ICT-based lighting system needs to be modifiable in order to upgrade or extend the system if needed to make it future-proof. Factors in assessing this are:

- The number of foreseen upgrade options over time
- The scalability of the system
- The understanding of the system boundaries and inherent limitations

Business aspects

Next to the criteria derived from the societal impact and functional requirements, the smart ICT-based lighting solution will have to comply with additional criteria related to the pre-commercial procurement process. The smart ICT-based lighting system needs to provide a sound business case for the short and longer term. Factors in assessing this are:

- The feasibility of the complete system within the time frame of ENIGMA
- The business perspective with the smart ICT-based lighting solution on the longer term (beyond the pilots in ENIGMA)

As the call is aimed at developing generic solutions that could potentially be applied in all European cities, the market potential for these new developed cities is enormous. The city specific challenges, are of a diverse nature; resembling the diversity of challenges that could be encountered across Europe. A smart system solution that is functional for these five cities; has a good chance to be useful and appreciated for an extensive number of European applications.

Modularity

The smart ICT-based lighting system needs to be modular in order to fit the design of the installation to specific needs and to facilitate the maintenance of the system. Factors in assessing this are:

- The well-founded architecture of the system and module interfaces
- The standardisation of the interfaces (mechanical, electrical, software)
- The interoperability of modules
- The interchangeability of the modules
- The understanding of the applicability of the system for diverse contexts

Openness

The smart ICT-based lighting system needs to be open in order to connect it to other systems and to enable other systems to connect with the lighting system. Factors in assessing this are:

- The accessibility of the network and infrastructure
- The accessibility of modules
- The accessibility of the data
- The accessibility of knowledge gathered with the system
- The connectivity of the system to other relevant systems, applications and domains

Appendices

The Appendix lists the input from the partners collected in the workshop on 15 January 2014 in Stavanger. The raw input from the partners is presented in order to keep the procedure transparent. It is admitted that the definition of a functional requirement was not easy and it can be disputed whether all inputs in the Appendix are functional. However, the final requirements can be seen as functional, since they refer to the wanted functions of the solution without being too specific about the precise technology to be used.

Results of the workshop to collect requirements

As part of the workshop on 15 January 2014 in Stavanger, the inputs from the ENIGMA project partners was collected on requirements for smart lighting solutions.

The requirements are clustered into five groups.

Repetition is not removed in the lists but it indicates the frequency of the requirements.

(The text in brackets in italics provides some additional descriptions.)

Adaptability

- Light on the right places *(no stray light)*
- Right monumental lighting
- Dynamic lighting to represent and communicate city rhythm (events, life etc.)
- Possibility to change light distribution
- Adjusting lighting according to user
- Right light on right time
- Dimmability
- Dimmability
- Give no light pollution
- Dark sky preservation, low polluting lighting
- Colour
- Colour
- Give the feeling it is “natural” like sun-rays, not artificial
- ADHD avoidance *(=related to the quality of light)*
- Motion sensor
- Right light distribution
- Avoiding femur fractures *(=related to quantity of light and lighting design)*
- Locally adaptable to the surroundings (right amount of light locally)
- More light with more activity
- Adaptive depending on type of presence
- Physical easy adaptable light source (minimum impact on the environment)
- Variations in light (intensity, direction, colour)
- Adjusted to the users in the area
- Preserving urban environment
- Give aesthetic effect on surroundings/nature
- Traffic jam signalling *(=informing about traffic jams)*

Interactivity

- Controlled by users
- Interactive
- Combine light and music (sound)
- Gaming
- Design on demand
- Advertising
- Surprised with something new
- Intimate contact with my friends *(=socializing)*
- Mood light: light which detects the mood you are in and reacts
- Users switch off lighting in many methods
- Monitoring various events and report
- Guidance
- Full controllability

Modifiability

- Scale adjustable
- Transferable
- Easy to program and maintain
- Flexibility

Modularity

- Modularity
- Modularity
- Modular (“Lego” building blocks)
- Maintenance
- Well operated
- Modularity
- Reasonable maintenance (costs + equipment)
- Discrete design (subtle)

Openness

- Open system (upgradeability)
- Open solutions
- Open systems
- Open modular system
- Connectivity
- WiFi

This report presents the results of the research into the Requirements for Smart Lighting Solutions carried out as part of the ENIGMA FP7 Pre-Commercial Procurement project (Work package 1, task 1.6). The research was done by the Lighting Unit of the Aalto University and the Intelligent Lighting Institute of the Eindhoven University of Technology, both partners in the ENIGMA project.

In this final task of work package 1 the results of the earlier tasks are used to identify the requirements for the smart lighting solution that will be procured in the ENIGMA project. Furthermore a set of assessment criteria for the tender is proposed. These criteria will be further developed in work package 3.

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

Eindhoven, 28 March 2014

ENIGMA