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FINAL REPORT: ASSESSMENT OF ECONOMIC ASPECTS OF SMART LIGHTING SYSTEMS IN SELECTED PILOT AREAS AROUND THE BALTIC SEA

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CONTENTS

1 SUMMARY

This report summarizes the four parts included in this work package: analysis of existing knowledge, compilation of the most relevant information into factsheets, workshops in the pilot cities (to build a common understanding, evaluate ideas for the calculation tool and to elicit expert knowledge) and the development of an assessment and calculation tool.

The workshops revealed that an integrated approach to the economics of smart city projects in general, not only smart lighting, was apparently missing from all the pilot cities. Also, municipal operations are still strongly divided into departments and silos. We found that allocating Interreg funds to previously existing projects hinders the possibility for a truly innovative pilot.

The real options to implement "smart" smart lighting (as opposed to simply energy-efficient LED lighting with some diming control) are still uncertain, especially in relation to the economics of local development. Given a high degree of unfamiliarity with these themes within municipalities, we suggest that, beyond cooperation among cities in the Baltic Sea region, different types of local stakeholders be included as official pilot project partners in order to drive innovation. In relation to the economics of smart urban lighting projects, piloting new solutions would greatly benefit from inputs besides the different municipal functions. We would recommend partners from at least five other sectors: (i) electricity generation and distribution (e.g. local ESCO), (ii) financial services, (iii) stablished lighting technology products providers (e.g. Phillips, Signify), (iv) challengers from the startup community and (v) the local academic and research institutions.

The LUCIA project design seemed to assume that lack of finance and technological knowledge are the main hurdles for the diffusion of smart lighting investments. Interreg founding was thus provided to the pilot cities to overcome the finance problem and generate knowledge from an inter city cooperation and learning process. In general, whatever the budget available or the finance modes considered by the municipality, the diffusion of smart urban lighting could be greatly accelerated simply by improving the procurement process with a focus on economic and environmental sustainability. Our cooperation with the pilot cities was unfortunately limited to the planning phase, leaving aside the economics of procurements, but there is a separate work package in Lucia about Green Public Procurement (GPP).

From a policy and economic planning perspective, framing the problem of smart urban lighting investments as finding ways to accelerate their diffusion makes the unjustified assumption that there are not legitimate reasons for cities to *decelerate* their diffusion. A more useful approach could be to help EU municipalities to develop their decision making under deep uncertainty, thus allowing for context-specific alternative framings of what the issue is. This contextual decision support for policy makers would incorporate the (local) expert knowledge better than the goal-based approach of our report, where expert knowledge makes sense only as far as it supports the idea that more smart lighting investments are needed.

This report should be cited as Myllyluoma J., Lamuela Orta C., Tvrdý J., 2020. Assessment of economic aspects of smart lighting systems in selected pilot areas around the Baltic Sea. Report of the EU funded project "LUCIA - Lighting the Baltic Sea Region, Cities accelerate the deployment of sustainable and smart urban lighting solutions (BSR Interreg #R096 LUCIA), January 2020.

2 INTRODUCTION

This final report, compiled by the FCG Design and Engineering Ltd. (FCG) upon the order of Posintra Ltd., Finland, deals with the assessment of economic aspects of smart lighting systems in selected pilot areas around the Baltic Sea Region, implemented in the framework of the EU BRS Interreg project LUCIA - Lighting the Baltic Sea Region, Cities accelerate the deployment of sustainable and smart urban lighting solutions. The report provides up-to-date information on the economic and business potential aspects of energy-efficient city lighting. The produced information package, factsheets and economic analysis tools are aimed at increasing knowledge of the planners and decision-makers and help them to promote and adapt innovative lighting solutions.

Figure 1. Waiting and ready for the first workshop launch in Porvoo, October 1, 2019. Photo by Topi Haapanen.

3 ASSIGNMENT – ECONOMIC ANALYSIS OF SMART URBAN LIGHTING

FCG's assignment was part of the LUCIA project implementation and its WP2 GoA 2.2, coordinated by Posintra Ltd, Finland.

LUCIA ?	= LUCIA - Lighting the Baltic Sea Region, Cities accelerate the deployment of sustainable and smart urban lighting solutions (an EU BSR Interreg project, #R096 LUCIA), www.lucia-project.eu
WP2 ?	= Work Package 2 - Global analysis of energy efficient urban lighting solutions
GoA 2.2. ?	= Group of Activities 2.2. – Economic aspects and business models

Table 1. Explanations of the LUCIA abbreviations.

The objective of the Work Package is to compile and produce a comprehensive, state-of-the-art analysis of the economic and business aspects of energy efficient and smart urban lighting.

The purpose of the information generated is to support the realization of LUCIA project pilot investments in Porvoo, Tallinn, Jūrmala, St. Petersburg and Hamburg. These five locations can be roughly divided into two types: **park area lighting** (Tallinn and St. Petersburg), and **lighting of pedestrian and cycling routes** (Porvoo, Jūrmala and Hamburg).

Figure 2: Pilot cities of Porvoo, Tallinn, Jūrmala, St. Petersburg and Hamburg. Photos by Visit Porvoo, Visit Tallinn, Latvia Travel (Jūrmala), Visit-Petersburg.ru, Destination Europe (Hamburg).

Posintra Ltd. has subcontracted the implementation of economic analysis to the Finnish expert company FCG Design and Engineering Ltd. (www.fcg.fi, later FCG). FCG's main goal is s to compile and produce a comprehensive, state-of-the-art analysis of the economic and business aspects of energy efficient and smart urban lighting, and the specific tasks within the assignment are:

- information collection and benchmarking,
- facilitation of local expert workshops that support the other tasks,
- elaboration of factsheets on the topic,
- development of a calculation tool to support design and evaluation of smart lighting investments.

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WP2 GoA 2.2. co-ordination	FCG's overall assignment, workshops	Calculation tool	Benchmarking Factsheets
topi.haapanen@posintra.fi	jaana.myllyluoma@fcg.fi	jan.tvrdy@fcg.fi	carlos.lamuela@fcg.fi

Table 2: LUCIA WP2 project manager of Posintra Ltd. and FCG Design and Engineering Ltd. (FCG) experts, responsible for the assignment (e-mails for further information)

The work process was organized to be iterative with the pilot cities project managers. We reviewed existing benchmarks and asked preliminary questions about the pilots to form hypothesis about how to improve chances of meaningful innovation and of positive economic results. We then summarize these into preliminary fact sheets that were discussed at the workshops. Our understanding of the issue was shaped in every workshop, so the information presented to the participants evolved throughout the workshop series. Concerning the calculation tool, its goals, possible impact and reasonable information inputs where discussed in all workshops.

4 INFORMATION COLLECTION AND FACTSHEETS

The initial task was to compile existing knowledge on the economic aspects of energy efficient and smart urban lightning, in Europe in particular, with the goals of pre-assessing the economic aspects of the five LUCIA project pilots to later synthesize this knowledge, together with the lessons learnt in the workshops, into easily usable factsheets supporting the dissemination of such projects in other municipalities.

The themes to be addressed were:

- Key performance indicators (KPI) and quantifiable variables
- Life cycle costs (LCC)
- Business models
- Multi-dimensional economic benefits
- Strategic planning

4.1 Thematic benchmarking and literature review

The keywords to focus the research for this report was defined in a LUCIA partner meeting according to two different target groups.

For policy makers:

1. key figures and indicators
2. strategic planning
3. waste and recovery

For experts:

4. life cycle costs
5. business models
6. multifunctionality

During the process the themes were integrated into the four different aspects exposed in the factsheets. The key sources of information for the recommendations and statements we make appear as references at the end of each factsheet.

4.1.1 Theme 1: Key figures and indicators

Task: to define key performance indicators (KPIs) and other quantifiable variables that can be best used to define the benefits of smart urban lighting investments.

Our initial research question was:

- *What are the best indicators and measurement criteria to define the economic success (including environmental benefits) of smart urban lighting? (e.g. ROI, EROI, carbon dioxide emissions, etc.)?*

Concerning alternatives to the obvious indicator options (return on investment and payback time), we found that the use of Net Present Value, although more technically appropriate for cash-generating investments such as solar energy (benchmark 2.3.), was challenging for the context we were working in (planners and technical departments) and did not bring any value related to securing finance. Energy return of investment, EROI, was also considered as a measure of systemic sustainability, but did not easily fit the available information about lighting projects. The indirect economic benefits proved impossible to be turned into quantitative indicators, besides qualitative considerations (e.g. promoting or not promoting outdoors activity and assumedly therefore savings in public health costs).

Benchmark case 2.3: Recent literature from solar energy investment and real estate economics:
Vimppari & Junnila: Estimating the diffusion of rooftop PVs: A real estate economics perspective. Energy, 2019.

This paper points out the convenience of using NPV as an indicator to analyze solar energy investments from the logic of enhancing the value of the underlying real estate.

Figure 3. The Mueller Austin solar array in Austin, Texas, United States. This a series of 18 to 20-foot tall flower-shaped sculptures that collect solar energy to light the buildings at night. (Wikimedia Commons / Larry D. Moore)

We also investigated the effects of the current context of low interest rates, since the discount rate is central in the sustainability debate (e.g. how to weight the cost of investment vs. the cost of not acting now). In relation with KPIs, showing that the project finance works could unlock financing mechanism for lighting investments, if external finance is the bottleneck preventing smart lighting dissemination. The challenges around market-based financing models had been investigated in a previous EU project (Streetlight-EPC: energy performance contracting), and we found out that these challenges were not related to the modelling of the investment itself, but to institutional issues requiring substantial facilitation to be overcome.

Benchmark case 1.1.: EU Streetlight-EPC Project (2014-2017):

Main findings & conclusions

Main findings and conclusions in a nut shell:

- Lack of trust in ESCO scheme (EPC, PPP or similar),
- Strong facilitation needed (for all stakeholders in ESCO projects – public authorities, ESCO companies and financial sector),
- Lack of interest in ESCO scheme due to availability of grants or cheap capital (in some countries),
- Public debt may be a decision factor in some countries,
- Long term contract duration due to low energy prices,
- General lack of EPC/PPP model understanding.

Such long-term facilitation program was beyond the scope of this LUCIA GoA, but the existing regional facilitation bodies from the EPC project should be contacted if possible.

4.1.2 Theme 2: Strategic planning

Task: to describe how the economic aspects of smart urban lighting should be considered as part of the strategic planning of cities.

Our initial research question was:

- *How could budget-constrained cities advance their smart urban lighting investments?*

We benchmarked compilations of cases were cities had succeeded in implementing energy efficient street lighting projects with different approaches.

Figure 4. Integrating lighting investments with municipal economic planning. Caption from the above-mentioned World Bank report, page 23.

Benchmark case 1.2: Proven delivery models for led public lighting: synthesis of six case studies. World Bank, Energy Sector Management Assistance Program Knowledge Series 026/2016.

The report suggests different delivery models for different municipal financial contexts:

Situation	Action	Delivery Model	Examples
Does the municipality have sufficient resources to fund the program itself?	Allocate funds by establishing budget line item for project	Municipal Financing Model	• Quezon City, Philippines • Ontario, Canada (cities opting for the Design-Upgrade-Transfer model)
Are there ESCOs active or planning to be active in the local market?	Negotiate an energy service performance contract with ESCOs	Private ESCO Model Public ESCO Model	• AEL, India • EESL in Vizag, India • Ontario, Canada (cities opting for shared savings EPC model)
Are leasing or private financing programs available?	Determine eligibility criteria and negotiate financing agreements	PPP Model Lease to Own Model	• Guadalajara, Mexico • Birmingham, UK

Figure 5. "Potential Delivery Model Options".

Thus, the mainstream approach to integrate lighting investments with municipal economic planning seems to be advocating for more market-based financing models. However, the context in the EU is challenging for the wider adoption of these practices (see above the EU EPC-Streetlight report) and specifically the LUCIA pilot cities were not considering this direction.

Integrating smart urban lighting in the broader entrepreneurialist governance that cities practice to booster their local economies proves difficult, because besides energy savings, benefits for developed cities are not immediately apparent. In the Baltic Sea Region, all basic urban activities are already relatively properly lighted and the gains from supporting nighttime economic activities are marginal.

4.1.3 Theme 3: Waste and recovery

Task: to consider how the economics of waste and recovery, and the more general effects in the environment, affect the overall economic benefits from smart urban lighting.

Our initial research question was:

- *How could the economics of waste generation and recycling and the environmental aspects be used to support the diffusion of smart urban lighting investments?*

Following the interest of the pilot cities, we investigated specifically the ecological impact of smart lighting around the themes of light pollution and its negative impact on insect, bats and other species . We did not find research that would support smart urban lighting investments from the point of view of the waste generated to produce smart lighting products, or the costs of fully recovering and recycling substituted products. For example, an interviewed official from the German municipality of Fulda (awarded for their night skies program) claimed that the city is substituting streetlamps only at their failure rate (not changing still functioning lights). However, a better view of this issue might be found from the LUCIA workpackages dealing with technology (TalTech) and procurement (Gate21)

Figure 5. The Fulda Cathedral lighted at night (image: Wikimedia / Lukas Hüfner). Protecting dark night skies from light pollution does not imply the demise of all special lighting.

4.1.4 Theme 4: Life cycle costs (LCC)

Task: to study how a life cycle cost approach could support the wider adoption of urban smart lighting.

Our initial research question was:

- *Is the lack of LCC approaches a real bottle neck preventing the faster adoption of urban smart lighting?*

The technology lifespan is a key driver of overall costs and the municipalities perceive this as a factor of great uncertainty. We interviewed technology providers that stressed how savings in maintenance cost are alone a good enough economic reason to implement these investments (savings are argued to come from the remote monitoring of the lamps, reducing the number of servicing visits and therefore the amount of workforce costs). Changes in energy price and use of renewal energy also affect the life-cycle costs of investments, but in opposite directions (energy price is expected to go up, but the associated $C0_2$ emissions are expected to go down).

We could not find strong evidence that there would be a significant difference in the life-cycle costs of traditional and new lighting technology (and disruptive economics from associated data platforms remain just a future promise, driven mostly by 5G producers, see for example the multi-million product development project by Nokia Bell Labs “LuxTurrim 5G Smart Street Lights”).

Additionally, in the case of a clean energy production context, such as the case of the LUCIA pilot city Porvoo in Finland, energy consumption savings become in theory irrelevant (as there is no green gas emission associated with lighting), so that it would make economic and ecological sense to only substitute broken street lights.

4.1.5 Theme 5: New Smart Lighting Business models

Task = to identify, describe and analyze new business models in energy efficient urban lighting and potential of different ownership and service production models. Impact of ownership of light poles and ground will be examined.

Our initial research question was:

- *What new business models could support municipal economics around urban smart lighting?*

Business models vary from traditional product and system sales to multi-functional, platform-economy based smart solutions. Potential business model variations are presented here considering different approaches (e.g. lighting as a service vs. as a networked platform for other services), and their combinations (synergy with 1.4) and impact on traditional marketing and sales channels and revenue models. As described in the figure below, the role of lighting is expanding along with emerging of new, connected functions and industries.

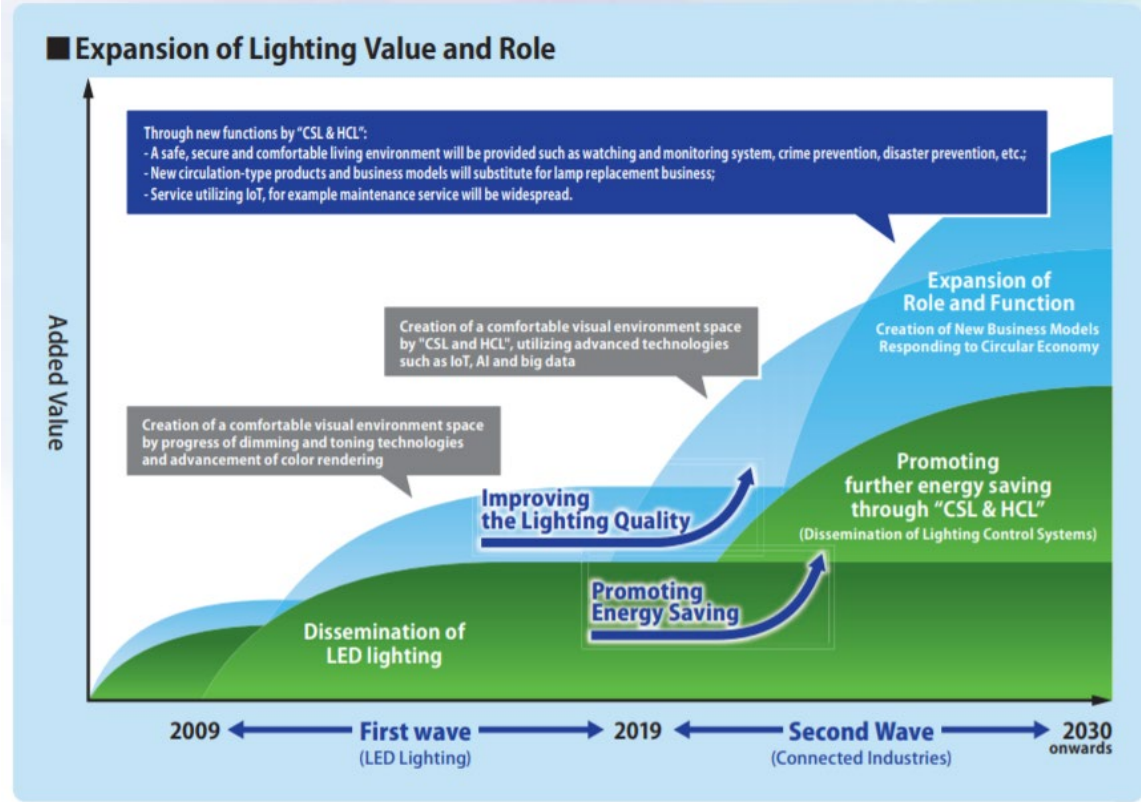


Figure 6. New business models evolving along with the connected industries. Source: Lighting Vision 2030 https://www.jlma.or.jp/about/vision/pdf/LV2030_webEM.pdf

In the figure above, "*CSL*" refers to an intelligent lighting that connects to a variety of things and matters, and "*HCL*" to a safe, comfortable and convenient lighting that is friendly to human.

In general, new smart lighting business models are for the time being relatively unclear and there are plenty of uncertainty factors. There is a certain over-optimism from the technology producers (e.g. the roll out of 5G networks is already much delayed from the initial grand visions and timeframes, by which we should now, as of 2020, already have working 5G networks). We also found that the industry side did not answer to our requirements for more information about their plans, possibly because of concern about competitors or closer scrutiny from consultants. Things being this way, the municipalities themselves must approach possible technology providers and evaluate for themselves what is the likelihood of successful integration with their economic plans. The so called European Green New Deal, an ambitious investment program still to be defined, might nevertheless change this context quickly, in favour of centralized support for public investment in sustainable transformations.

Benchmark case 4.2. Nokia Bell Labs research and development project "LuxTurrim5G" (Piloting at the city of Espoo, Finland)

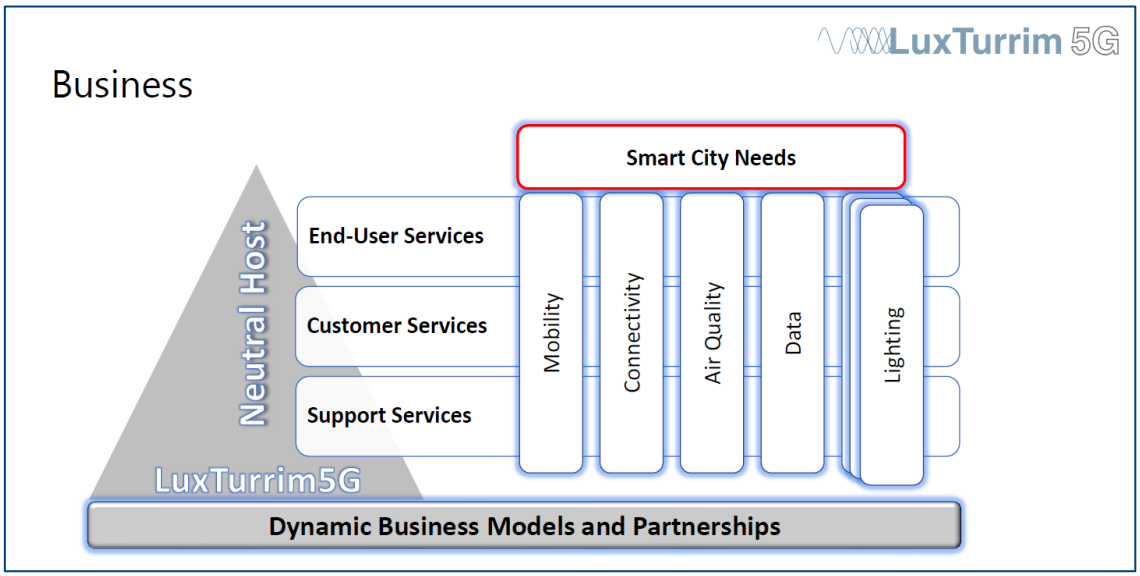


Figure 7. Dynamic business models and partnerships of LuxTurrim 5G (https://www.luxturrim5g.com)

LuxTurrim5G is a Nokia Bell Labs driven ecosystem project that develops and demonstrates fast 5G network based on smart light poles with integrated antennas, base stations, sensors, screens and other devices. It aims at opening new digital services and business opportunities for a real smart city. The first phase LuxTurrim5G ended in May 2019 and successfully developed the 5G smart pole concept with integrated 5G base station, weather and air quality sensors, video cameras, monitors electric vehicle charging unit and other active devices. LuxTurrim5G+ is the second phase of the development, where altogether 26 partners and well over a hundred experts in various fields are working closely together to develop and evaluate new solutions. LuxTurrim5G+ focusing on the productization of the smart pole concept and extension of the 5G smart pole pilot network in Kera neighborhood in Espoo, while the Neutral Host Pilot project focuses on data-driven business and service development, intelligent network construction and operation models.

Benchmark case 4.3: Research project SenCity. Piloting Intelligent Lighting and User-Oriented Services in Complex Smart City Environments. (University of Oulu, VTT Technical Research Center of Finland).

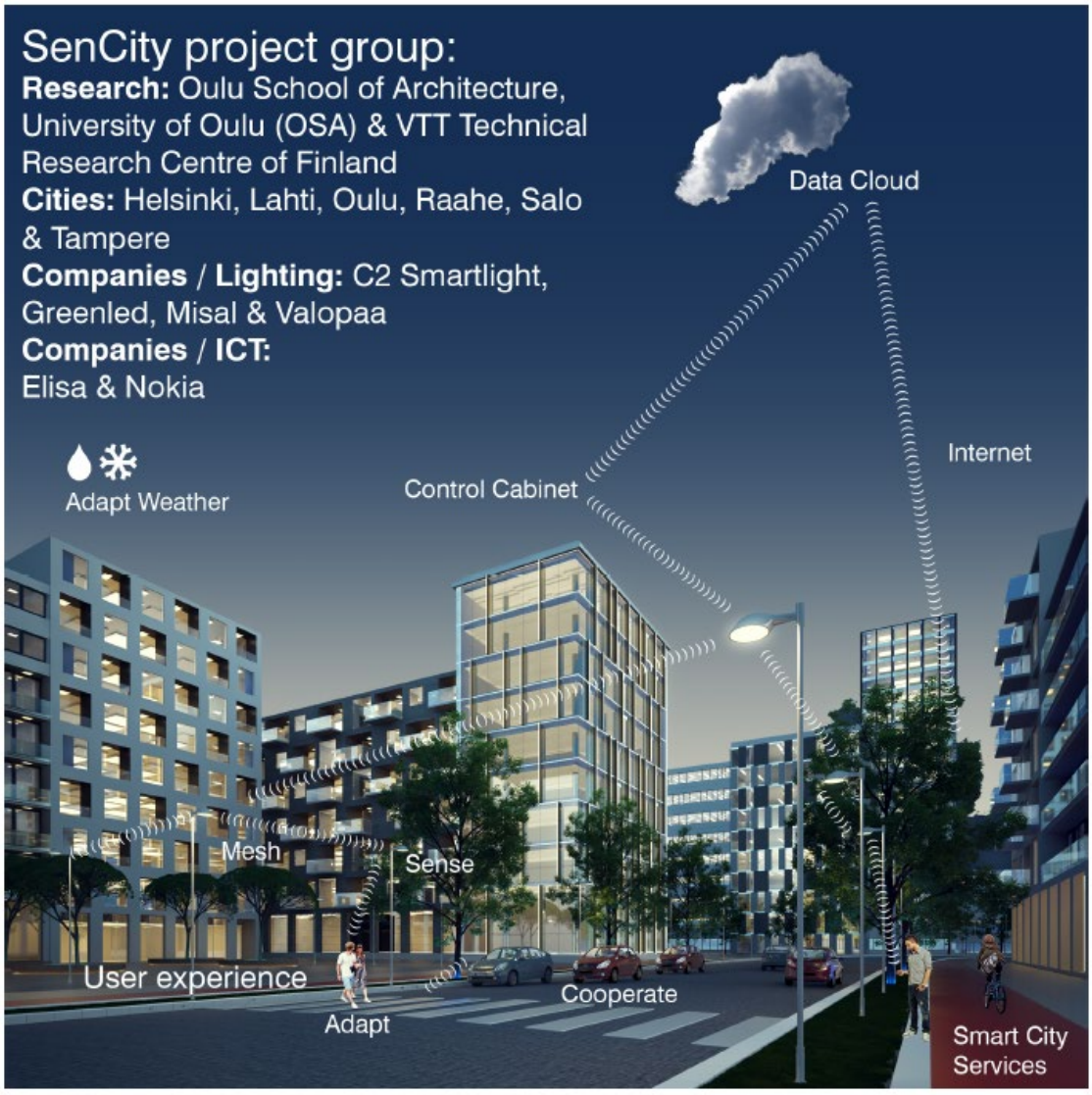


Figure 8. Research project SenCity, University of Oulu and VTT Technical Research Centre of Finland.

SenCity paper abstract (Henrika Pihlajaniemi et. al.):

This paper addresses the design and research of intelligent lighting and user-oriented services for smart city environments. It presents the problem setting and research and development methods of the SenCity project. The project will pilot smart lighting solutions in six Finnish cities in different kinds of urban environments. In the pilots, the target is to employ lighting infrastructure as a service platform – an Internet of Things backbone - in the intelligent city. Together, separate pilots in different cities around Finland will create a living lab ecosystem for developing and testing innovative solutions. The specific objective of this paper is to present the concept of a platform as defined and applied in SenCity project. The **presented framework forms an operational model** for creating intelligent lighting and digital services in smart cities by **integrating** relevant technologies, users' needs, and business **into an interactive system**. In the paper, the framework is applied to a selection of pilot cases with specific themes to introduce its usability in real world implementations.

Comparison of business models

The business model examples presented below are not comprehensive, since business models are still evolving and may differ case by case. Especially in the case of non-traditional service-oriented models, there are different kinds of new or renewed service providers on the market that are still evolving. The applied division of models is simplified and presents the models from the provider's point of view.

Traditional product/technology sales (purchase from the buyer's point of view)
The traditional product (technology/system sales) consists basically of two approaches: a) Sales of LED lamps or other lighting technology b) Installation and maintenance of lamps (so called product-as-a-service)
City approach: Traditional procurement of equipment, focus on price, technical performance and energy/cost savings Ownership of poles/light units: City

Hire & Lease
Short term hiring of lighting equipment e.g. for events and festivals. Usually connected with other audio-visual solutions and packages.
City approach: Short-term renting solutions, usually tailored Ownership of technology: Service provider

Long term leasing (leasing contract)
The service provider leases the lighting solution and can also offer leasing funding (e.g. Philips, Osram). Example: the municipality sells street lighting infrastructure to a private contractor conditional on upgrade, operation, and management. The municipality then leases it back from a private contractor for a fixed fee over a set period. Ownership rights are generally transferred back to the municipality at the end of the leasing contract.
City approach: Leasing of technology Ownership of poles/light units: Service provider during the leasing contract

Light as a Service (LaaS)
LaaS can consist basically of two separate or synergic approaches: • Performance approach (e.g. efficiency, technical performance) • Impact oriented solutions, added value (decorative lighting, atmosphere, emotions, feeling of security e.g.) In LaaS the city purchases light rather that the technology. LaaS allows to avoid an upfront lump sum capital investment for new lighting. It provides the option to pay for the upgrade as

an ongoing operating expense. It should be less than the energy cost savings and result to a positive cash flow.
City approach: Purchase of light, not equipment. By reducing risks and simplifying the acquisition process, LaaS may facilitate a lighting upgrade that otherwise might be delayed or not approved at all. In addition, it enhances adoption of more advanced features such as intelligent control, connectivity and data collection. But, as the end-user is tied to the terms of the agreement for its duration, and as sometimes happens in payment programs, the overall cost can be higher than paying up front. Ownership of poles: Usually city

Multifunctional performance as a Service
Lighting system or its units (e.g. poles) can serve as a platform for other services (security, monitoring, tracking, displaying, charging etc.). Earnings can come from sales/rent of space, technology or performance for different functions. A system integrator compiles a comprehensive solution.
City approach: Need for consideration during design and planning of purchase/procurement. If no multifunctional purchase, at least need to require from lighting technology interoperability with evolving future technologies or offer parts of the lighting infrastructure as a living lab platform for public-private development partnership. Ownership of poles/technology: Depends on the case

There also newcomers in the market that can be characterized as smart system or service integrators. Typically, traditional lighting companies such as Philips, Osram etc. have been reforming their business from traditional sales to service integration.

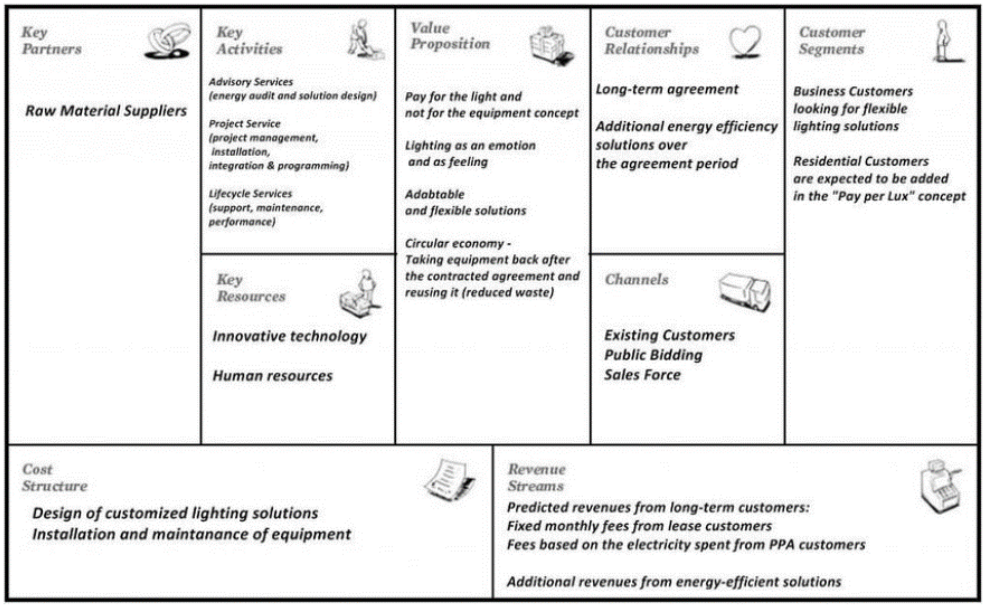


Figure 9. Business model canvas for Philips lighting services.

Business models are in close interrelation with applied project finance, procurement, and operating and maintenance models. The division of business models below is simplified and presents the models from the provider's point of view. When approaching the topics from the angle of cities, elements of financial and procurement models are also relevant. Correspondingly, operating and maintenance models are deeply connected with financing and procurement models.

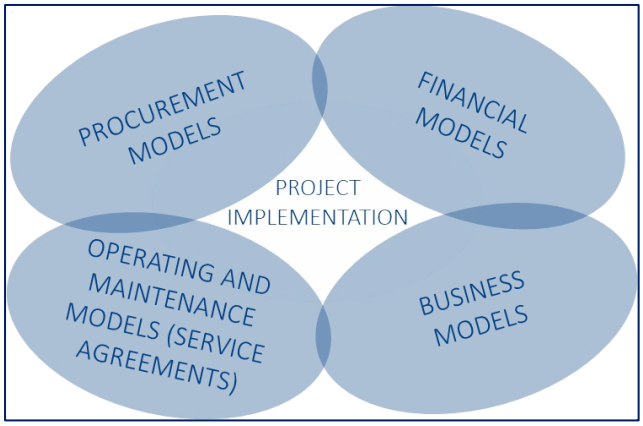


Figure 10. Interrelation of business models with other key aspects of lighting project implementation.

The figure below presents basic financial models for municipal street lighting investments. The most straightforward option for a municipality to upgrade or purchase lighting solutions is to pay for it from its own budget funds, but there are also several other options to be considered. Grant funding is applicable especially when the project has challenging goals and innovative approach.

Figure 11. Financing models for public street lighting investment (Adapted and reformulated by FCG from Novikova, A., Stelmakh, K., Hessling, M., Emmrich, J., and Stamo, I. 2017.)

The main considerations when choosing a financing option for the lighting investment are the availability of own budget funding and resources; the city's credit capacity, project size and profitability (bankability); availability and market maturity of service providers and energy service companies (ESCOs); and, finally, strategies and policies of the city and also financial incentives on EU and national levels.

Detailed information on financial models is available, for example, in the following documents:

- https://www.interreg-central.eu/Content.Node/Dynamic-Light/CE452Dynamic-Light-D.T2.3.3-Best-Practice-Guide-final.pdf
- https://h2020prospect.eu/images/Module_Handbooks/Module-on-Public-Lighting.pdf

Along with financing, it is necessary to think about the appropriate **procurement model**. For experts and designers dealing with lighting, burdened with everyday work, implementation of procurement can sometimes be very challenging. Smart lighting technology is developing fast and, on the other hand, they may lack the needed expertise and tools. For example, it may not be clear from the beginning how to ensure that the technology to be procured will be smart and up to date for a long time.

When applied systematically, the public sector can create demand for innovation and thus inspire companies to develop smart solutions. At the same time, the quality and efficiency of public infrastructure such as lighting can be improved. Innovative public procurement provides an environment for companies to develop and experiment with new solutions. Businesses receive important references to help them grow and gain access to wider and even international markets.

Adaptation of new procurement models requires new skills and operating methods from the cities. From the companies' point of view, municipal procurement is a strategic tool of industrial policy, which creates pressure to develop municipal procurement expertise and procurement policy.

Much of municipal expenditure comes from procurement. The efficient and high-quality organisation of procurement is in the common interest of municipalities and companies. Entrepreneurs, on the other hand, will have open and realistic opportunities to compete for purchases in the municipal sector.

How should we then define smart, innovative procurement that responds to the requirements above, when even the term "innovative procurement" alone can arise unwillingness to cooperate among responsible planners and designers? Innovative procurement can mean that you either implement the process in a novel way (e.g. spend time and effort on market dialogue or innovative partnerships) or that the desired result is innovative.

One possibility is to take small steps and avoid too complex approaches to innovativeness. Thus, we are recommending three simple rules for the definition of smart procurement model:

- The procurement is implemented in a novel way and not via the traditional "only price matters" option.
- The process delivers a good and desired outcome.
- All parties involved are satisfied.

When should you then apply innovative procurement methods? A good starting point is to assess strategic importance, the level of challenge and project size with the following questions ("step 1"):

- Is the project important and/or necessary from the point of view of the municipal strategies or programs?
- Is the market lacking solutions to fit your needs and to be easily adapted?
- Does the project have goals with challenges above standard implementations?
- Is the acquisition significant in euros?

If getting one or more yes answers, think about answers to the following questions ("step 2"):

- Innovativeness for the city
    - Possibility to develop or renew existing infrastructure, operating model or service
    - Possibility to create new infrastructure, operating model or service
- Innovation for the supplier or service provider
    - Opportunities to promote or develop the company's own operations, provided by the acquisition
    - Potential for development of existing products or services, provided by the acquisition
    - Potential for development of completely products or services, provided by the acquisition
- Business impact
    - Availability of local providers of the desired product/service
    - Operational or economic significance for local suppliers
    - Possibility for local businesses to form a consortium with each other
    - Possibility for local businesses to form a consortium with non-local, innovative companies
    - Local growth and innovation potential (growth via reference via the project)
- Impact on regional economy
    - Significance of the procurement volume on regional level
    - Significance of the size of the acquisition for the city/region

  - Significance of the size of the acquisition for local businesses
  - Significance of the size of the acquisition for a local business sector
  - Impact of the procurement method on the achievement of the most economically advantageous tender (MEAT)
- Environmental and social impacts
  - Positive impacts on environment (e.g. energy efficiency, circumstances for flora and fauna, circular use of resources)
  - Broad social effects (e.g. employment, safety, accessibility and equal rights

The questions and exemplary checklists above should help planners and designers to identify if extra effort for the procurement and the overall project is worth making. They also provide a tool for highlighting for decision-makers a non-numeric justification of the additional resources needed, together with numeric calculations such as presented in Chapter 6 (Calculation tool). Smart and sustainable procurement benefits not only the purchasing municipality itself, but also wider society and economy of the city. It can bring direct and indirect benefits, minimise environmental damage or even enhance the quality of the physical and social environment.

4.1.6 Theme 6: Multifunctionality (Multi-dimensional economic benefits)

Task = to describe and analyse the economic and synergy benefits that different smart city solutions and other innovative technology applications can offer for urban lighting solutions. This section is deeply connected with the task 1.3. Business models

For example, the light pole can be more than just a light device. Technology can benefit city management (e.g. mobility, recycling), as well as tech and non-tech enterprises (trade, marketing, tourism, events, outdoors/sport, security etc.). This topics section is deeply connected with the business models.

It is possible to use multifunctional light poles for different functions - including commercial purposes and revenue generation - by including different applications or devices in light poles or other illumination units. The possibilities for light poles equipped with sensors or other technology is almost limitless, for example (in no particular order):

- Traffic lights
- Street signage
- Power outlet fittings (e.g. for outdoor pop up -shops)
- Festive decoration
- Banners
- CCTV
- Speakers

- Security equipment
- Wi-Fi connections
- Charging stations for electric vehicles
- Management of bike sharing
- Tracking of objects and people
- Monitoring environmental parameters
- Waste management

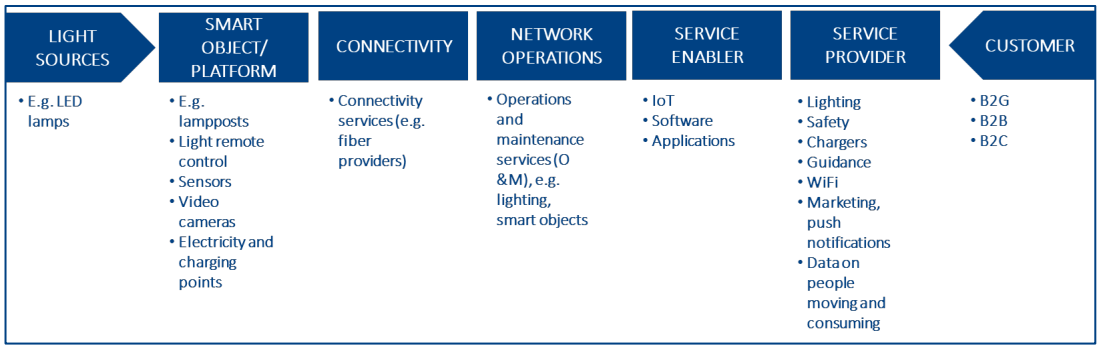
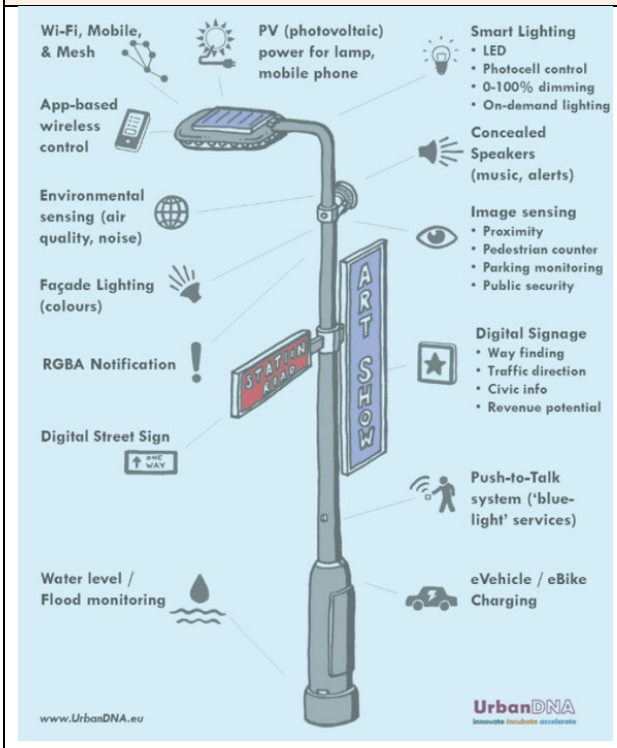


Figure 12. Smart urban lighting value chain. Source used and reformulated by FCG: Arthur D: Little analysis

Examples of multifunctionality

A dozen smart ways to use a lamppost that has nothing to do with light



Read more: https://eu-smartcities.eu/news/lampposts-are-one-quick-fix-smart-success; Humble Lamp-post Survey Insight Paper: https://eu-smartcities.eu/sites/eu-smartcities.eu/files/2018-01/EIPSCC-Humble%20Lamppost%20Survey%20Insight%281%29.pdf

Ceiling lamps beam information to shoppers' smartphones

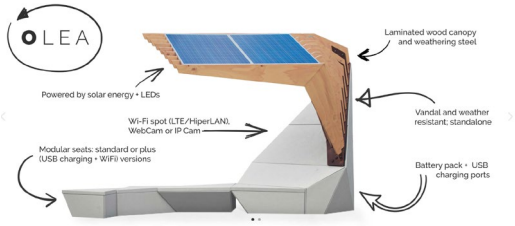
France's Carrefour, one of the world's three largest retailers, steers shoppers straight to discounts and products via led lights in the shop ceiling.

LEDs are semiconductors ('light-emitting diodes') and therefore programmable. A VLC system encodes light waves with data about products or promotions and transmits to the camera on a shoppers' smartphone.

An app then displays the information and helps guide the consumer to the product's location in the store.

Read more: https://luxreview.com/article/2015/05/welcome-to-the-new-business-model-of-lighting

Smart & solar powered benches



Read more: http://greensocialbench.com/en/olea_eng/ (Italy); http://www.digiledsign.com/street-furniture-advertising/solar-bench/smart-bench-solar-powered-advertising-light.html (China)

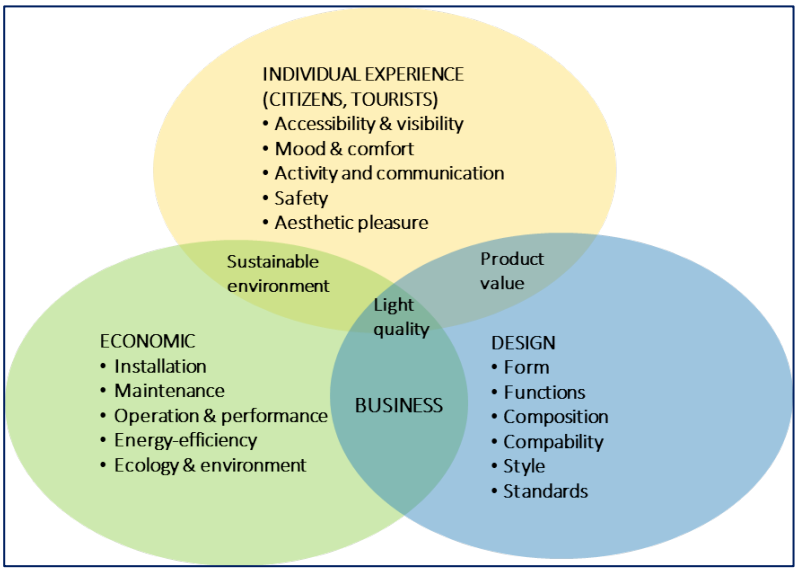


Figure 13. Elements of business models and multi-functionality in relation to light quality. Adapted and reformulated by FCG from Lighting Quality, Veitch 2011.

Lighting and tourism

Besides its central influence on the quality of life of permanent inhabitants, lighting can enhance attractivity of the city for tourists - i.e. basicly be the very reason, or one of the eminent reasons to come. On location, lighting can support the fulfilment of basic needs of tourists e.g. in terms of safety, accessibility, comfort and guidance, conveying a warm and friendly atmosphere. The figure below presents examples of different aspects and benefits of lighting in terms of urban tourism infrastructure and economic preconditions.

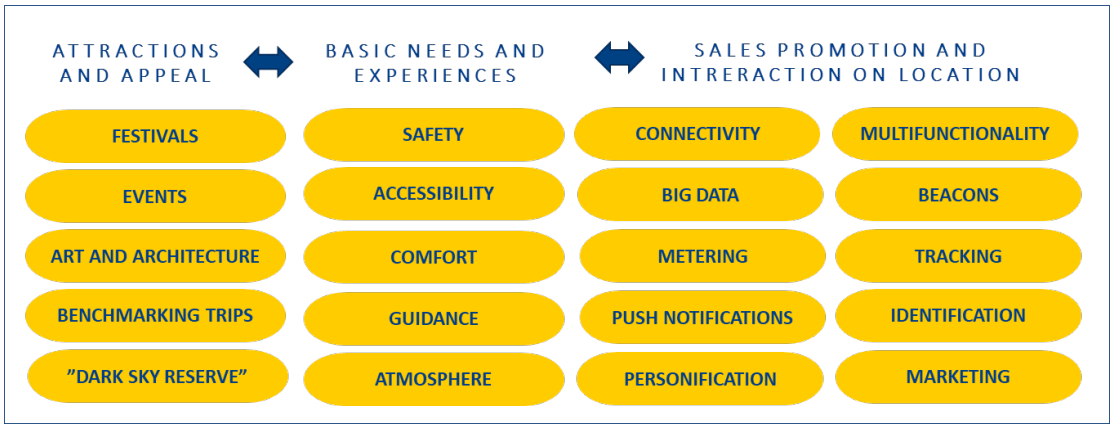


Figure 14. Potential of lighting for urban tourism (FCG 2020).

Smart beacons will allow tourism destinations to monitor how visitors interact and flow in the city. This gives attractions and city planners a mean and tools to systematic improvement of the tourist experience. City planners can also utilize the collected "big data" for planning of infrastructure – flow of visitors, and correspondingly, requirements towards transport and mobility infrastructures and development of MaaS (Mobility as a service) in PPPP framework (public-private partnership + people).

Multifunctional technologies allow different kind of sales promotion and interaction with tourists on location. A single smart lamppost can provide an electricity supply point for pop-up shops during urban festivals or events. Smart lighting innovative use of light to emphasize and highlight urban and/or historical art and architecture, as well as light events and festivals, can be the main reason to choose a destination.

Breathing light for public space, Breda City, Netherlands

The Lux lab in Eindhoven developed the vision 'breathing light' for the public space. Breathing light is light which is tailored to the needs of people at a certain moment. It doesn't only include light in relation to human activity. The light can also move along with other factors such as the seasons that change throughout the year, the identity of a city, the weather or the reported mobility.

Read more: https://innovationorigins.com/smart-light-eindhoven-brings-breda-city-prize

4.2 Factsheets

We include here a one-page executive summary of the economic factsheets, as they will be released in their final form after graphic design and approval from the project partners.

1. Smart urban lighting and city economic strategic planning

What are the key strategies to link economic development and smart urban lighting?

Besides energy savings, smart lighting supports the transition towards long-term sustainable economic development of cities.

2. KPIs, finance and delivery models of smart urban lighting projects

How to finance smart urban lighting investments?

There are many options, but the most important strategy is to assess your city's procuring capabilities and break free from budget-deficit inaction and siloed administration approaches.

3. Life cycle cost assessment of smart urban lighting investment decisions.

Why and how to include a life cycle approach to smart urban lighting investments decisions?

Life cycle cost (LCC) analysis tries to define the long-term economic costs of an investment. The use of LCC for the urban smart lighting case is challenging, given a high level of uncertainty

4. Multifunctional technology and new business models in Smart Urban Lightning

How to reach economic benefits from multifunctional smart urban lighting?

It is crucial to design a well-functioning economic, institutional and contractual framework, adapted to the local context.

5 LOCAL EXPERT WORKSHOPS

The LUCIA Local Expert Workshops explored the economic aspects of energy efficient urban lighting and provided participants up-to-date information about the topic. Interactive workshops were organized during October-November 2019 in five pilot cities:

- Porvoo, Finland
- Tallinn, Estonia
- Jūrmala, Latvia
- St. Petersburg, Russia
- Hamburg, Germany

Figure 15: Workshops in Porvoo, Tallinn, Jūrmala, St. Petersburg and Hamburg. Photos by Topi Haapanen.

The main tasks of the workshops were:

- Co-creation of knowledge: increase the participants' awareness on economic aspects and allow the consultants to learn from the pilot case to benchmark it for the LUCIA project.
- Evaluate the existing economic information about the pilot site and its specific needs to gain understanding for the development of the economic assessment tool.

In terms of invited participants, the aim was to increase their knowledge on economic aspects and potential of urban lighting, and to offer to the pilot cities & sites up-to-date thinking about the facts & possibilities of for economic benefits from smart urban lighting. Workshops may be comprehended as a platform for local discussions, ideas and perhaps some worries. An important question was to identify what the most relevant information from economic point of view would be to support the cities in the pilot site realization - and beyond that, in the future efforts and decisions after the project.

Posintra Ltd. and the FCG Design and Engineering Ltd. from Finland – together with the local LUCIA project managers – were responsible for the workshops.

The target groups were lighting and financial planners, urban planners, power grid experts and energy companies of each pilot city – i.e. people that are daily/regularly working with lighting issues. Urban decision makers as well as other stakeholders dealing with lighting solutions of the targeted pilot areas were also welcome.

The workshops provided FCG experts with a good channel to discuss about the expected outcomes with representatives of LUCIA cities and get new viewpoints to the pilot site and overall economic evaluation.

CONTENT AND TOPICS OF THE WORKSHOPS

Economic aspects were the focus in each city, but the specific points of interest varied depending on the character of the pilot location.

Economical and cost benefit aspects of…	
Porvoo	… investing in new infrastructure
Tallinn	… creating alluring public space lighting
Jūrmala	… creating of an attractive tourism area
St. Petersburg	… new technologies in smart urban lighting investments
Hamburg	Economy of the city lighting - environmental opportunities and challenges

Table 3. Workshop headlines and topics in the pilot cities.

The workshops included presentation of interesting international examples and interactive discussion of the economic base of each pilot site together with the participants. In general, new viewpoints to economic aspects of the pilot site design were discussed and evaluated together.

In each workshop, the following questions were presented and discussed

- Benchmarking of economic aspects smart urban lighting economic aspects with the following aims:
  - to find and understand innovative cases (or simply implemented) of smart urban lighting projects (from the point of view of the economics),
  - to support LUCIA pilots, and
  - to support adoption of smart urban lighting in the Baltic (overall goal of LUCIA project)
- Factsheets

- FCG's task = to draft 4-5 factsheets demonstrating the most relevant aspects of smart urban lighting (SUL) from an economic point of view. The following picture indicates the benchmarking case-studies (CS) and related factsheets (FS) that were discussed during the workshops.

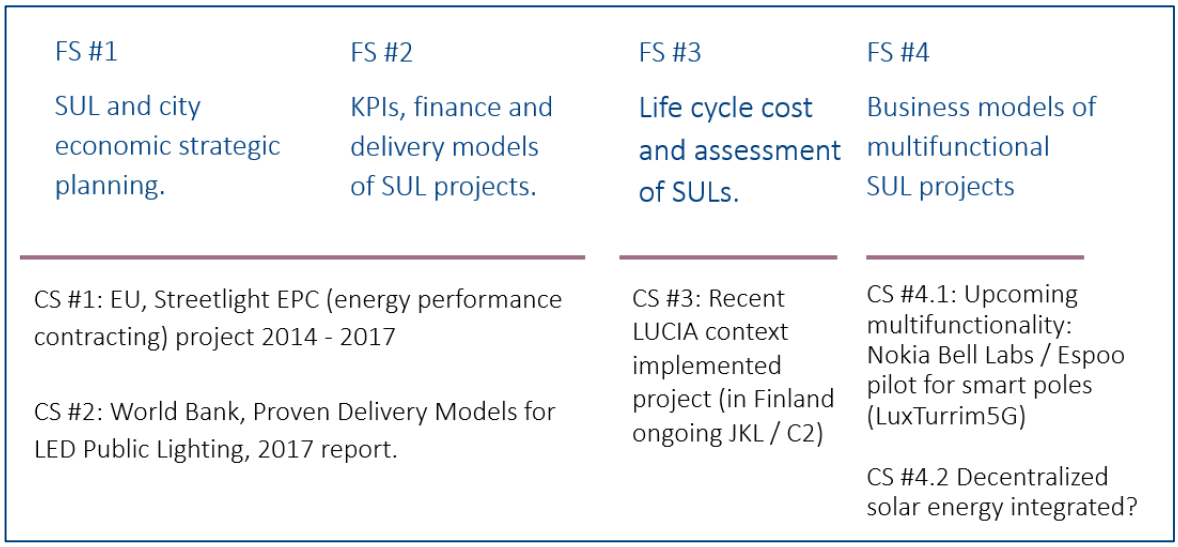


Figure 16: Proposed factsheets (FS) and benchmarking case studies (CS). KPI = Key Performance Indicator.

- **Identification of different aspects of planning and decision-making (economic viewpoints)**

  A negotiation game was implemented in four workshops: Porvoo, Tallinn, Jūrmala and Hamburg. The goal of the game was to help the participants to identify different aspects of decision-making, including roles, responsibilities, budget, bottlenecks, ownerships, and reflect them towards the pilot project.

  Exemplary results of the negotiation game applied are presented on page 31 (Hamburg workshop.)

Method	SMART URBAN LIGHTING PROJECT NEGOTIATION GAME
Description	Each participant was given an imaginary role with a request to read the instruction (suggestions) in a specific role card. Then the role persons negotiate and try to agree on: 1. The scope of the project (type of smart urban lighting technology and % of city street luminaires replaces with it) 2. The cost and calendar of the project 3. Who will take care of what
Roles	1. City technical or planning manager / expert 2. City financial manager / budget decision-maker 3. Energy company 4. Smart Lighting product provider 5. Local bricks and mortar entrepreneur 6. Technology entrepreneur (local or big multinational) 7. Local activist / politician
Role	Motivation /suggestion

City technical or planning manager / expert	- You want to improve the lighting of a certain city area which is part of your current project, or in this year urban planning program. - You are interested in new technology, as it means less maintenance costs, and you want to keep up with your field development. - If you hear about making the project larger, you are aware that your unit does not have resources to accomplish a larger project, involving all the city. Also, a tight calendar does not sound too good, you would prefer if there aren't time expectations putting more pressure on your team.
City financial manager / budget decision-maker	- You want to reduce the overall costs of running the city, but you have a limited budget for investments. - Starting now to reduce carbon emissions is crucial, to keep up with the City's pledge to different sustainability goals. - You may consider alternative financing models, but you are aware that financing costs may rise (relative to just using the budget) and that the increased technology implies more risk in the long term.
Energy company representative	- You have a great plan about how your company will develop future energy production, distribution and urban lighting, and you are concern that other stakeholders do not really understand the energy sector.
Smart lighting product provider	- You would like the project to be as large as possible, as you will sell more of your products and have a better project referent. - You support anyone asking for "more technology" in the project, because you want to deploy your latest products. - You cannot finance the project; you want it to be paid upfront or at the end of implementation at the latest.
Local bricks and mortar entrepreneur	- You are mostly concerned about the project being ready for next Christmas season, so that it helps clients find your shop. - You rather see a small and feasible project happening soon, not a technological innovation; however, if all lighting around the historical area, where your shop is, could be redesigned with higher standards, it would be even better in your opinion.
Digital technology entrepreneur (small and local / big and international)	- You would like the new urban lighting to include an additional technology feature because A) Your business idea needs this digital platform (local small entrepreneur) and you are ready to pay a fee to use it. B) You have developed the technology (big international firm) and you are ready to deploy it financing most of the cost. - However, in both cases, the others do not understand what this is about, so you can only tell them that you want "more technology" and assure them that it will have "positive economic impacts" (there is a lot of uncertainty about what the business models are, or whether they will work, but you remain optimistic).
Local activist/ politician	- You are concerned about the overall impact of this project in the city, including all aspects besides energy savings. - You have one theme that you are especially interested in putting forward, regardless of cost (e.g. reducing light pollution, increasing the amount of light around schools and in intersections). - You want to see a justification why to invest in this, instead of investing in other equally important themes requiring funds.

- Calculation tool

  The basic assumptions for the tool, presented in the workshops, are:

  - The tool is Excel-based.
  - It's focus lies on evaluating and showcasing the economic impact of new and energy efficient lighting solutions
  - The tool deals with numbers + quality + glue between them.
  - Main users of the tool are urban planners and infra designers

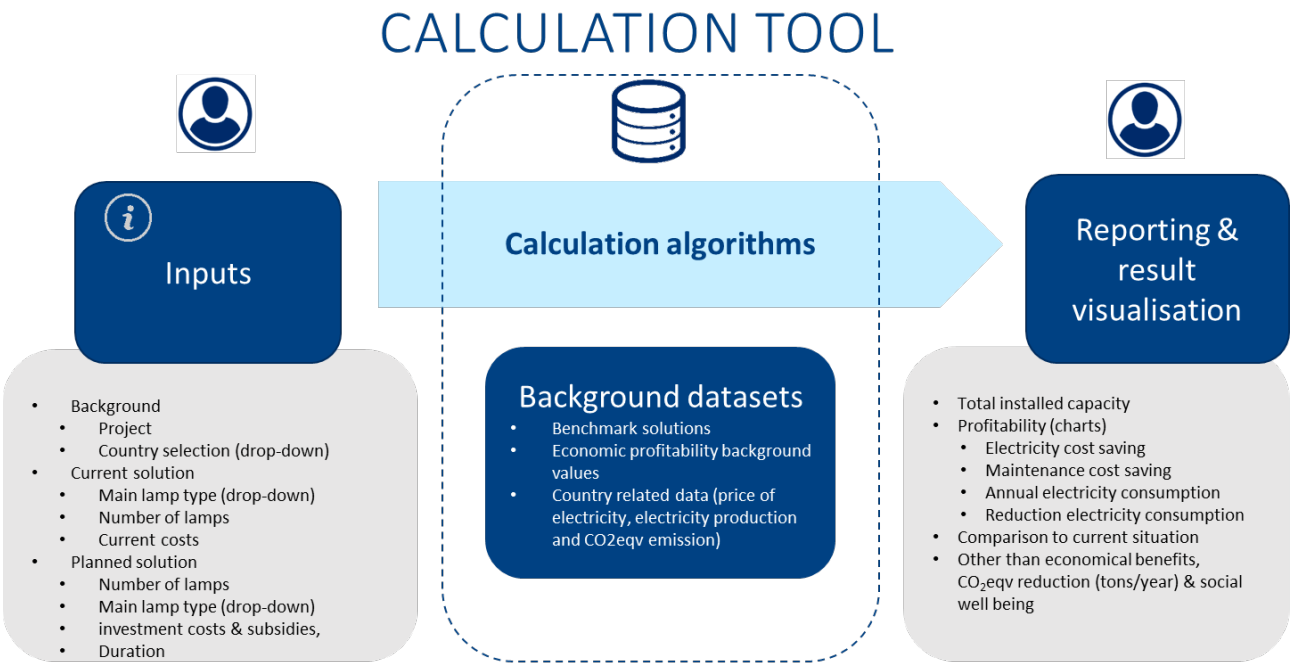


Figure 17: Draft structure of the calculation tool to be developed

5.1 WORKSHOP SERIES

5.1.1 PORVOO WORKSHOP

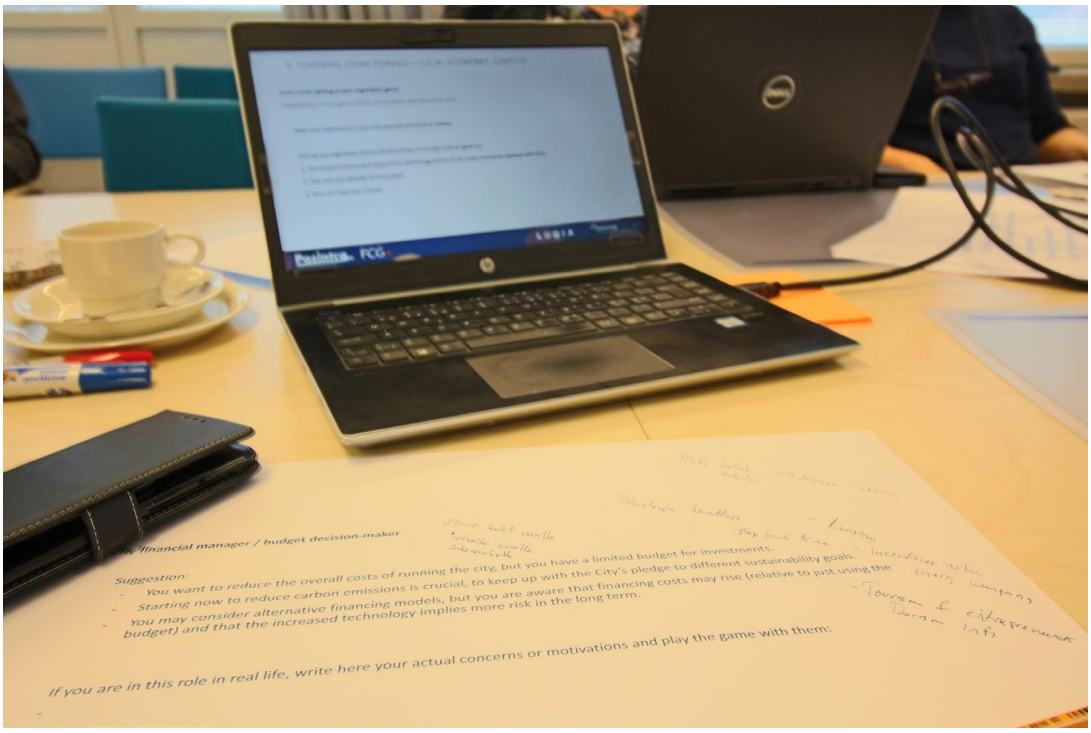


Figure 18: Workshop tools in Porvoo. Photo by Topi Haapanen.

Meeting title	PORVOO WORKSHOP Economical and cost benefit aspects of investing in new infrastructure
Location	Porvoo, Rihkamatori
Date	1 October 2019, 8.30-12

PORVOO PILOT PROJECT PRESENTATION

https://www.lucia-project.eu/pilot-sites/porvoo-finland/

The pilot project deals with a walking route illumination with a certain uniqueness connected with the location, which is totally new city area under development.

There are some challenges and parallel processes:

- The path does not exist yet.
- Different future operations and buildings are planned to the area.
- Width requirement relating to possibility for cycling

- Construction of the waterfront wall, stabilization of the river bottom where necessary
- Underground constructions
- Uniqueness: totally new city area to be developed

Some facts from Porvoo:

- 16,000 lamps in the area, from which 3,000-3,500 LEDs. Mercury and metal-halide lamps replaced first, priority on the mercury ones.
- The process of replacement has started from the city center and is spreading around. On average, 1000 lamps are replaced per year.
- There is a compilation map available = an open fault information service that covers all luminaires. GPS measurement with types of luminaire.
- Challenge: how to find a suitable model for the Old Town and historical parks of Porvoo?
- The City owns the energy company Porvoon Energia. The engineering department pays to the company more than EUR 1.5 million a year for street and road lighting. There is a fixed price for light units (the number of replaced lamps does not have any affect). Based on this - what are the actual benefits for upgrading the network for the energy company?
- Which incentives motivate the city? A challenge for the strategic planning: how plans and projects are enhanced and how the different parties are committed to it. “More light, but also energy saving.” Avoiding excess moves is also important.
- Construction of new streets and park corridors on average comprises 100 km per year in Porvoo.

FACTSHEETS AND BENCHMARKING

Discussion and comments from participants:

- You must consider also **ecological aspects**, e.g. bats. The season for bats in Finland is very short. Light attracts moths and moths - bats. Orientation and frequency of light is important here. (Note: ecology and light pollution are especially important in the Hamburg pilot).
- Synergic potential of **lighting and tourism** would be an interesting benchmark – not just investment costs, but also increase of market value. Possible case: Rovakatu Street in Rovaniemi, Lapland, designed by FCG.
- When planning light festivals or events, you must be very careful how you illuminate items.
- Economic approach does not exclude qualitative issues.
- Light and art - light allows you to bring art in places it would be otherwise impossible. Atmosphere, stories, attractiveness during dark hours + indirect economic impacts.
- Will the fast development of technology make cables old-fashioned?

Porvoo, Finland	Kalmar, Sweden (2016)
Population 50.000	Population: city centre 48.000 (whole municipality 64.000)
Budget approx. 140.000 €	Investment costs: 165.000 € (no subsidies, EPC model)
	Number of streetlamps updated: 49 (average cost 3.367 €/lamp)
Porvoo project details?	Installed electric capacity: 6,5 kW (before, HPS) > 2,1 kW (after, LED)
	Annual consumption reduction: 65% (27.400 kWh > 9.000 kWh = 18.400 kWh)
	CO2 reduction: 7,6 tons/year (2.421 kWh = 1 ton CO2 vs. Finnish/Porvoo grid?)
	Electricity cost savings: 2.000 €/year (3.000 € > 1.000 €)
	Maintenance cost savings: 1.300 €/year
Porvoo and Porvoon Energia	ESCO (Kalmar Energi) was going to renew the cables, offered EPC for whole renewal
overall situation?	Kalmar conducted inventory of public lighting systems to address renovation needs

Payback time:
50 years (!?)
Contract time ?

Kalmar #2, village (Sweden, 2016)
Population: 64.000 (Kalmar) / 70 (Förlösä village)
Investment costs: 70.000 € (no subsidies, EPC model)
Number of streetlamps updated: 25 (average cost 2.800 €/lamp)
Installed electric capacity: 2 kW (before, HPS) > 0,6 kW (after, LED)
Annual consumption reduction: 71% (8.370 > 2.390 = 5980 kWh)
CO_2 reduction: 2,8 tons/year (2.421 kWh = 1 ton CO_2 vs. Finnish/Porvoo grid?)
Electricity cost savings: 660 €/year (920 € > 260 €)
Maintenance cost savings: 660 €/year
ESCO (E.On/One Nordic) was going to renew the cables, offered EPC for whole renewal
Kalmar conducted inventory of public lighting systems to address renovation needs

Payback time:
53 years (!?)
Contract time ?

Figure 19: Benchmarking references presented in Porvoo (Source: EU EPC projects)

CALCULATION TOOL

Discussion and comments from participants:

- The City of Porvoo lacks a cross-sectoral implementation group that would already in the planning phase elaborate a general plan with calculation of investments and social impact – the tool could benefit such group in their planning efforts and also in presentation of the plans for politicians ("this is the tool we use and trust")
- The tool could also help in comparison of costs
- Quality and social impacts as important as economic ones
- Basic focus: street lighting
- To inputs:
    - What do you want to illuminate (lighting as a solution)?
    - Social values that must be illuminated
    - Places for social gatherings
    - Accessibility for all groups, courage
    - Can you calculate passing walkers and cyclers (health and wellbeing impact)?
- Impact on quality

- Improvements in quality of the environment
- Value factors of place and milieu (e.g. fine parks, bridges)
- Surfacing of routes is also connected with lighting.
- Basic starting point and justification: welfare of citizens
- Additional construction is often accompanied by social quality. Consideration of social groups!
- One approach for the tool development: how to plan and implement your next project after the LUCIA contribution is completed.
- It is not clear who benefits from the savings: the city or the energy company.
- Porvoo Energy: Usually more money is budgeted annually on luminaire replacement than the company has time to replace in practice.
- Specific counters (installed e.g. at shopping center doors) measure outdoor use
- Outdoor areas are "running idle" for 6 months (dark autumn and winter months), the time for reduced mobility of the elderly people. Norwegians have calculated the big savings that money and efforts spent on mobility and operating capability of senior citizens can bring. Maintenance of streets must be combined with this overall objective (de-icing etc.).
- The current control system in Porvoo adjusts the whole system and you cannot select a specific part of it (e.g. decorative lights vs. streetlights). Yet, there are controllers with 3 different relays, and you could ask the Greenstreet company (system provider) whether the above control would be possible (e.g. switching on only decorative lights at a certain timepoint). The problem is that they take the electricity directly from outside lighting poles.
- The LUCIA pilot route in Porvoo would need a double cable to allow multifunctional uses.
- The tool should be a tool to indicate achievement of goals – is it possible to include target parameters? E.g. carbon neutrality targets of the city
- Flexibility, adaptability for user's needs and multiple uses enhance user friendliness. The tool should not be too tailored i.e. only for some specific uses.
- It is important to identify "sensitive points" that have a big impact
- Demerging lighting for light traffic from lighting for cars
- Plans are presented at first to boards of politicians. Attached studies and reports come often back like boomerangs
- If you do not make special efforts on the deployment phase, the tool will be wasted.
- Other than economic benefits: e.g. assessment of user potential can produce numbers (e.g. how big group of citizens can move to cycling)
- Considering ethnographic groups and equality, e.g. better connectivity of suburban areas to the city center
- Electronic visitor counters (e.g. used by the Finnish Metsähallitus in national parks)
- Distinction needed, for example, in the following:
    - Using the tool should not take more time than logical reasoning
    - Strategies vs. experiments
    - Can't the tool be used for optimization of maintenance?
    - Is there a need for monitoring the achievement of results?

- Can the technology be portable?
- What is the ratio between parks and pedestrian routes vs. streets for cars? -> 5 %. Testing of new technology is easier in parks and corresponding places
- Lighting and winter maintenance go usually hand in hand.
- Determination: Why and for whom are the streetlights? Depends on the road type.
- Some history: when Porvoo started to illuminate the parks, there were no cars, only horse-drawn vehicles - and lights were indicating slippery places for them. Usually we think cars, pedestrian safety etc.

Figure 20. Porvoo workshop. Photos by Topi Haapanen.

5.1.2 TALLINN WORKSHOP

Figure 21: Pilot presentation in Tallinn about to start. Photo by Jaana Myllyluoma.

Meeting title	TALLINN PILOT SITE WORKSHOP Economical and cost benefit aspects of creating alluring public space lighting
Location	Tallinn, Tolli 4
Date	3 October 2019, 12.00 – 16.00

TALLINN PILOT PROJECT PRESENTATION

https://www.lucia-project.eu/pilot-sites/tallinn-estonia/

Some facts from Tallinn:

- The led adoption rate is 10 %.
- Consumption based payments to energy company are applied.
- The city does not own the energy company.
- Goal: energy consumption decreases by 2030: 30 (?) %
- Electric network belongs to the city.
- There is money available for good ideas.

- Currently there is only sensor for the whole city, switch on/off.
- Basic things are kept simple, specific ones paid more attention to.

Discussion and comments from participants:

- Could the next step be user interaction?
- The input from sensors should have some logics (programming), it cannot be constantly blinking
- In Porvoo, some of the main issues discussed were the role of energy company and municipality and are there any incentives between them.

FACTSHEETS AND BENCHMARKING

Discussion and comments from participants:

- Nokia benchmark is good: 5G enhancing capacity to build business models
  - Implementation? Separate networks by or one?
  - Is it too early to invest?
  - Currently there are Wi-Fi protocols, but the technology can change very fast.
  - **Technology is ready, but business models are still lacking.**
- Ads + lighting is common in Tallinn. In the future, there will be more combinations with novel business possibilities.

Porvoo, Finland	Fulda, Germany
Population 50.345	Population: 68.580
Budget approx. 140.000 €	Budget: aprox. 700.000 €/year, 10 year project
LED percentage: 20% (of 16.000 lum.)	Luminaires replaced: 1.150 (of 8.200 = 14%)
Adoption rate: 800 / year	Luminaires only replaced at end of life span
Time to full LEDification: 12 years	?
Delivery model: ?	Delivery model: municipality finance
Who pays / benefits from savings / benefits from other impacts	Bottlenecks: none reportedly, project planned and implemented in cooperation with municipal ESCO 'Osthessen Netz'.
Porvoo and Porvoon Energia case-study	

Figure 22: Some benchmarking takeaways for Tallinn.

CALCULATION TOOL

Discussion and comments from participants:

- Tallinn approach (even if there is money available for good ideas): Projects are quite low budgeted, and the tool might help in rising their volumes.
- **”Lighting is more than light”**
- Should there be scoring? (you cannot measure health in money)
- Feeling vs. being secure are different things.
- To tool input: desired lighting levels – luminance (what kind of activities the lighting should support). There is an issue with colour also.
- Flexibility needed – **light is a feeling**! What emotion do you want to create?
- Attractiveness for arriving visitors.
- Is it better to move quickly or wait e.g. technology? -> Today the solution for the whole city should be that we buy luminaires that are adaptable with different control systems and then acquire the system.
- Learning from others’ mistakes vs. risk taking and opening testing platforms for businesses - question from engineering companies
- Keeping things simple!
- Technology is not so expensive, and it is not the case. Why be concerned?
- Level of technology? Level of smartness?
- Safety solutions e.g. sensors tracking accidents (sound-based) – light indicating the location
- Light pollution? ->There is a standard, but not actually a problem in Tallinn.
- **Investment calculator/profitability vs. impact ”calculator”**
- Business models are important.

Figure 23: Tallinn workshop. Photos by Topi Haapanen.

5.1.3 JŪRMALA WORKSHOP

Figure 24: Latvian and EU flags in Jūrmala. Photo by Jaana Myllyluoma

Meeting title	JŪRMALA PILOT SITE WORKSHOP Economical and cost benefit aspects of creating of an attractive tourism area
Location	Jūrmala City Council – Jomas iela 1/5
Date	7 October 2019, 12.00 – 16.00

JŪRMALA PILOT PROJECT PRESENTATION

https://www.lucia-project.eu/pilot-sites/Jūrmala-latvia/

- Investments for Jomas Street lighting renovation 99 000 EUR, from which
  - 14 000 EUR for design
  - 80 000 EUR for building
  - 5000 EUR for construction supervision
- Hopes towards intelligent light functions on Jomas Street (most popular answers from the citizens):
  - Changes in the brightness of the lighting according to pedestrian flow
  - Analysis of pedestrian flow
  - Improving public security
  - Waste management (notice when bins are full)
  - Monitoring of the surface

- Road directions of offers sent to phone (push notifications)
- Shops and cafes would need electricity for street trade
- More than 50 % of recipients of the questionnaire think that the renewal is necessary
- *Where does the highlighting of safety/security in the answers come from?* It might be the general feeling (dark nights and long winter). Also, drunken people from Jomas restaurants in the evening vs. families with children.

Some facts from Jūrmala:

- Over 57 000 inhabitants
- Total energy use for street lighting in 2018: 3.917.506 Kw/h
- Cost of electricity: 0.144 EUR incl. VAT - current target 2020 price in Jūrmala city lighting net. Forecasts are updated periodically.
- Comparison of costs per inhabitant: Hamburg 9 EUR, Porvoo 30 EUR (incl. maintenance and reconstruction), Jūrmala 5 EUR (only the energy consumption)

FACTSHEETS AND BENCHMARKING

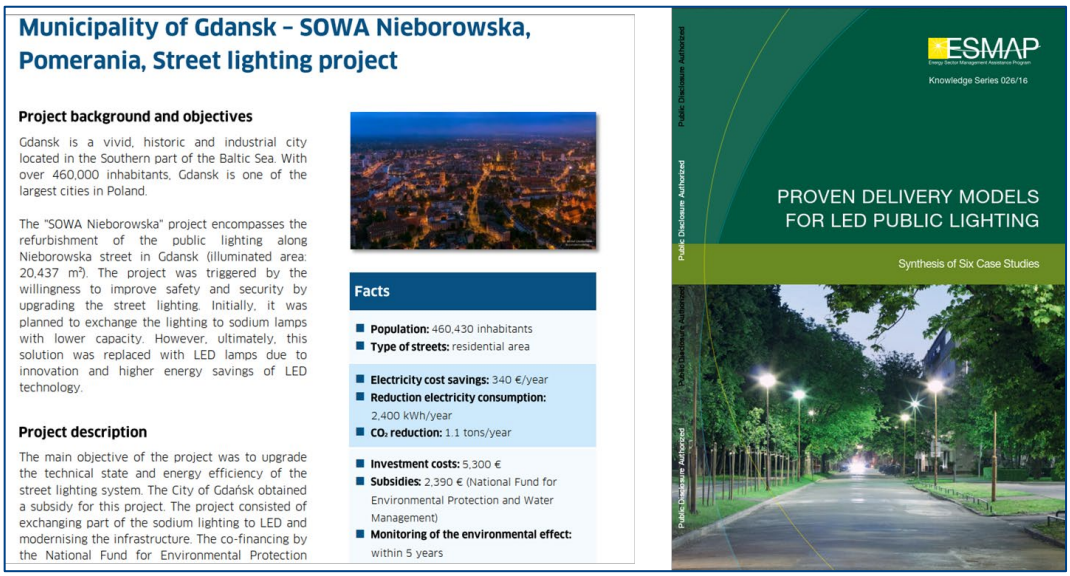


Figure 25: Benchmarking example discussed in Jürmala

Discussion and comments from participants:

- CO2 goals in Jūrmala, e.g. Pack of Mayors has been signed
- For decision makers money is number one.
- Risk: safety – surveillance – spying?
- New technology – how long does it really take?
- Heidelberg provides an example of disappointment with its introduction of new light poles.
- Municipal budgets are shrinking.
- Citizens in Jūrmala were most concerned about design ("not super-smart")

- Look to the future: Sustainable development goals (SDGs)[1] – how many of them does the lighting match? SDGs could help in showcasing the non-economic indicators in the calculation tool.

Figure 26: UN Sustainable development goals (SDG)

CALCULATION TOOL

Discussion and comments from the participants:

- Real feedback collection from "real people" (municipalities, no one has time -> utmost simplicity), testing at least among the Lucia people
- What is there beyond the numbers?
- Jūrmala has a GIS system under development – could it be connected to the tool?
- Different layers: Social impact assessment extension and environmental impact assessment

What must the tool indicate/be and what not?

MUST!	*NOT!*
Energy saving and costs	Millions of examples
New system costs	Many background models and algorithms
Lifecycle incl. maintenance (25 yrs.) and total costs	Tons of information on tech advantages
Show development areas (inhabitants etc.)	Unusable extra features or exceptions
Easy to use and easy to present to decision-makers (but data-based)	Complicated
Benefits beyond numbers, eq. benefits from smart features	Opportunities for misunderstanding
Good visual report	Different currencies and languages
Numbers, KPI, costs/inhabitant - at least some to enable comparison	Question based
Must be possible to integrate with GIS (database model) and urban development planning	

Table 4: Participants' expectations towards the tool

- 3 possible approaches for the tool:

[1] https://sustainabledevelopment.un.org/?menu=1300

  - Numbers (initial approach)
  - Externalities beyond numbers
  - Numbers + GIS/planning
- Combination of numbers and GIS would be ideal
- Could monitoring of achievements support the use of the tool?
- What should we achieve with the tool? -> Better planning?
- Who are the main users? -> Planners
- The tool could help directing a city planner's work: "I would like to do this and this to my people in this area, then calculate…". The tool should show which area is the next one (justification)
- Lifetime expectancy? In general: Jūrmala , Hamburg approx. 25 yrs. Porvoo 15 yrs. (Note: 2 parts - pole 50 yrs. or more, lightbulbs almost every year)

Figure 27: Workshop in Jūrmala. Photos by Topi Haapanen and Jaana Myllyluoma.

5.1.4 ST. PETERSBURG WORKSHOP

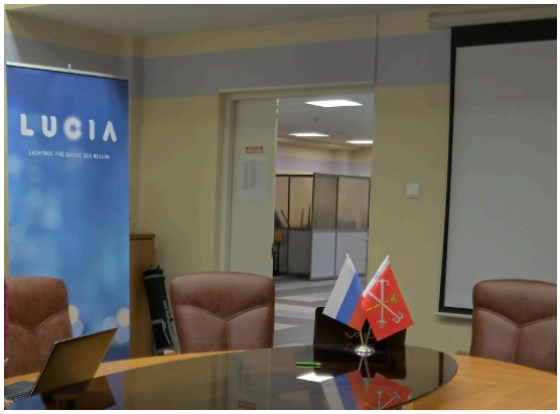


Figure 28: Quiet moment before the workshop start in St. Petersburg. Photo by Jaana Myllyluoma.

Meeting title	ST. PETERSBURG PILOT SITE WORKSHOP Economical and cost benefit aspects of new technologies in smart urban lighting investments
Location	Peter the Great St. Petersburg Polytechnic University (SPbPU), St. Petersburg
Date	31 October 2019, 9.30 – 14

ST. PETERSBURG PILOT PROJECT PRESENTATION

https://www.lucia-project.eu/pilot-sites/st-petersburg-russia/

- The pilot is focused on the central part of the campus (park area) – smart lighting design for the whole area, pilot implementation only along the straight axial path.
- Currently the territory of the main campus area lighting meets the standard norms and requirements.
- 250 light units, natrium (sodium) lamps, 400 W
- There are aerial and ground lines of electricity supply (goal to go full underground).
- Design of modern lighting has been going on for many years, but the area is under protection as monument of historical heritage, which means you must consult about numerous structures.
- LUCIA pilot goal: design of street lighting posts with modern technologies
    - Lighting where and when needed with necessary level (sensors)
    - Information network based on optic cable (fiber optics) for controlling the lighting
    - Video monitoring
    - Wi-Fi provision
    - Security, alarm system, panic buttons
- There is already a test ground built up (*see Fig. 14, lower part of the marked area*)
- Electricity network is also under the University's control, which is positive in terms of implementation.

- The Porvoo case has many similarities, while there will be a completely new infra. Porvoo has decided to build enough cables to secure multiple use potential in the future. Like St. Petersburg, Porvoo – even if smaller - is also a historical town with related challenges. The pilot area (park) does not have specific historical significance, but the soil is soft and challenging, and the pedestrian routes need fortification.
- Porvoo and St. Petersburg pilots are dealing with design of new lighting, no luminaire replacement.
- Geological aspects are important for St. Petersburg pilot, too (park environment). The weather condition is also similar in both cities.
- *Questions for Porvoo: Are there challenges in terms of exploitation and repairing of LEDS?* -> Energy savings are clear, but the savings on maintenance are interesting. Also, the expectations of people towards energy efficient and good lighting are in significant role
- Pilot implementation timetable in St. Petersburg
    - Term of reference are ready
    - Selection of designer company in the beginning of 2020, design by the end of 2020
    - Implementation during 2021
- Application of old stile lanterns is planned, there are old lantern drawings still available
- The cost of electricity for outside lighting is not currently calculated as a separate item. *Could it be 50 % of the total cost?* -> Probably – referring to share of exploitation.
- Lensvet practical experience and statistics show that drivers (источники питания) are mostly failing, and not the actual luminaires/lamps. Here the solution would be to replace the driver (access to the unit), but currently the constructions do not allow that (light modules are expensive, and so is their replacement). To summarize: the product construction should provide an easy and cheap way to replace the light module or the driver module.
- *Question: How to deal with technology risks of LED projects?* Guarantee by product providers; and including failure probabilities in project costs calculations.
- *Question: what happens in practice when a LED lamp stops working; how is it replaced?* -> Question for benchmarking (going deeper)

LENSVET PRESENTATION

Figure 29: Lensvet web page, http://www.lensvet.spb.ru/ (pages in Russian, used automatic Google translation)

Lensvet is the oldest and biggest outdoor lighting company in Russia.

*Operating area: St. Petersburg and its suburbs

*353 000 lamps, from them 53 000 LEDs

*148 000 lamp posts (the rest is facades etc.)

The main task is to maintain the central controlling unit (единый центр управления).

- Shift to smart lighting will be obligatory beginning from 2020.
- From 2020, launch of automatic control of LEDs, drivers with Dali protocol (government decree to have electronic drivers in public lighting), using a database with GIS.
- Goal: 100 % LEDS IN 2032
- 1 billion RUB (14 million EUR) goes for outdoor lighting electricity per year (directly from city budget)
- Energy savings already now are 80 million RUB (1,1 million EUR), mostly due to LED projects, 20% of lamps are LEDs
- City owns the lamps. Lensvet is responsible for their maintenance and service. City owns Lensvet (formally the Committee of Energy and Engineering). Expanding services to the

smart lighting sectors, parking, roads etc. represent additional business possibilities for Lensvet. Lensvet have posts on average every 30 meters (so data operators are approaching them with interest).

- Automation project (AIS+) with ITMO university: 11 districts analyzed – GIS (division: blocks, parks, streets)

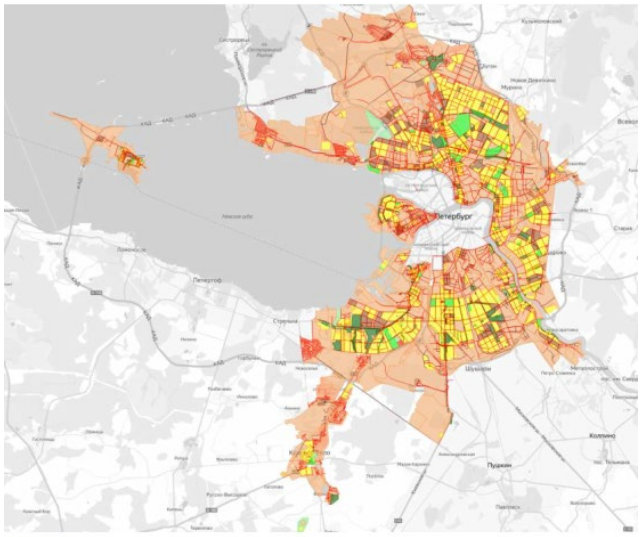


Figure 30: Status of 11 mapped districts

- Implementation of projects in the framework of the Program for comfortable outdoor environment (Программа комфортной окружающей среды) since 2018. Considering also disabled and physically challenged people (e.g. tactile experience for the blind, bicycle routes). Example:

  - Karpovka Promenade with river embankment.

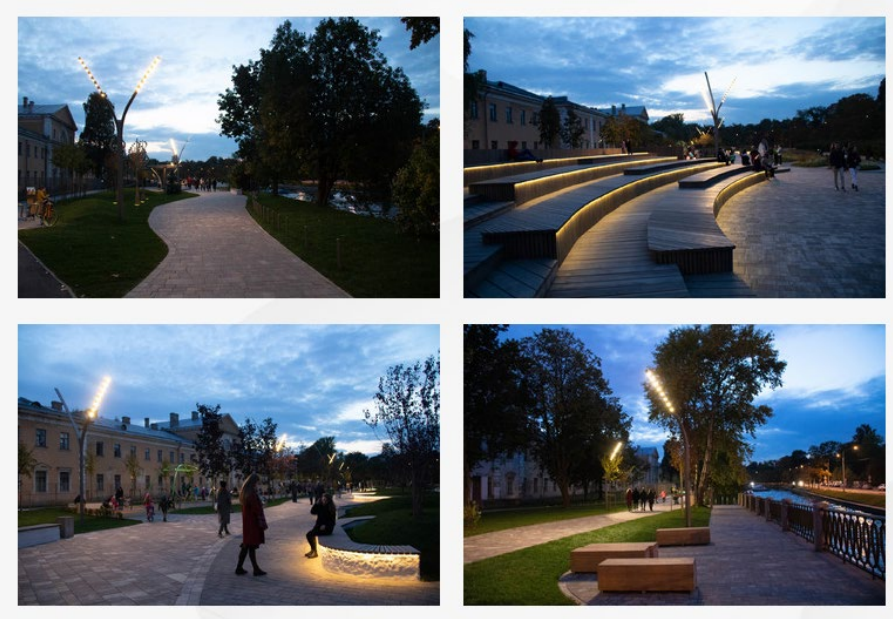


Figure 31: Karpovka promenade

- Application of projectors
- Working also with smart zebra crossings, individually controlled for diming and failure prediction.
- Smart lamp post (the usual technology-based development idea)
- Innovation development: automatization, digitalization, introduction of new technologies, artificial intelligence – goal to reduce energy consumption; sustainable and composite materials, coatings resistant to vandalism
- *Are there already suppliers?* Yes, there are some potential suppliers of lamp posts in the city.
- Sometimes the main obstacle is wide use of design form Moscow, not considering historical and other local values
- Main problems and challenges:
    - Quality of grid and reliability of energy supply (e.g. when dimming only light and keeping other sources in work)
    - Deterioration of networks
    - New approach to maintenance and related new services (now time-based control)
    - Service level. People are the most important part of the city. (This is also the Lucia project approach – people are the most important and wellbeing in the city.)
- LoRaWan network system (implemented and developed in Moscow), plan to use it in Petersburg for new areas
    - See lora-alliance.org, an open, non-profit association to promote a protocol for IoT LPWAN connectivity

FACTSHEETS AND BENCHMARKING

Questions for participants:

What is the challenge in investments, if the LED prices are going down 10 % per year and the interest rates remain low?

- Not only saving of money, you should consider also indirect benefits (косвенные преимущества!) like safety, comfort etc.
- In St. Petersburg there are basically no problems with funding - lamps serve 8 yrs., and the money comes from city budget

How can the benchmarking and factsheets help?

- Introducing experiences from outside Russia
- Showcasing examples of how you can combine different technologies in one lamp post (thinking about the smart part and showing how the whole design works, e.g. reliability -> DOLL, Nokia, C2S

What are the factors affecting the economics of your pilot project?

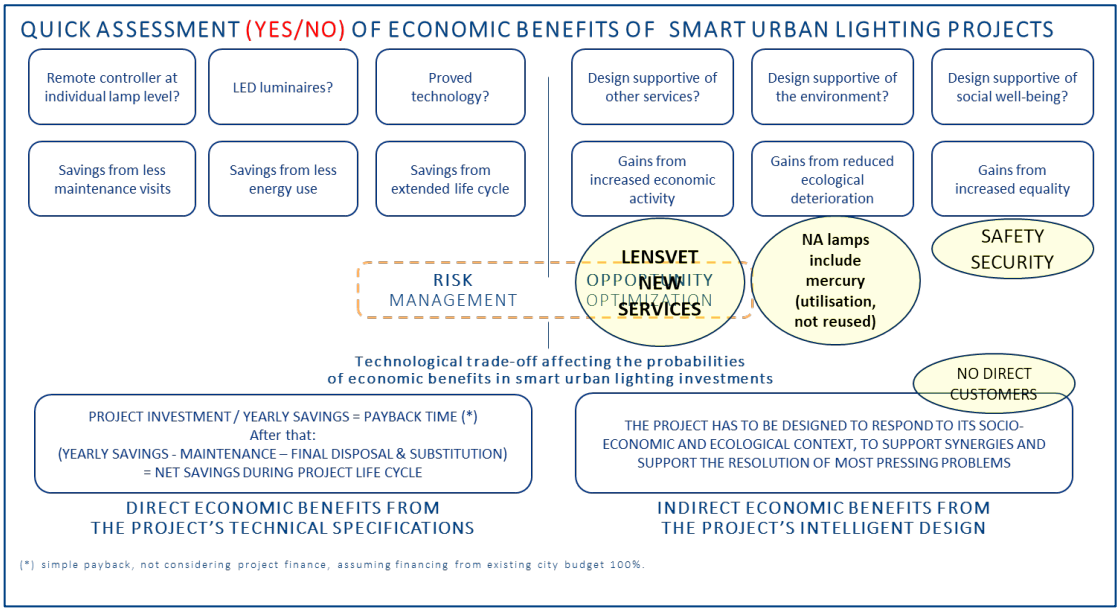


Figure 32: Influence map: "What are the factors affecting the economics of your pilot project?" Additions by workshop participants marked with yellow background

- Finding funding is not an issue for Lensvet, they have enough from the city budget.
- Currently using natrium i.e. sodium lamps (by GE and Osram).
- Cost of disposing natrium (sodium) lamps containing mercury
  - There is an organization that collects the lamps and extracts valuable components
  - Lensvet pays them for the disposal around 30.000 lamps/a x 0,5 RUB per lamp
- Note: Security and surveillance technology can sometimes be perceived as spying

CALCULATION TOOL

Discussion and comments from the participants:

- Data for calculation:
  - It is currently impossible to determine the maintenance costs per year at the University campus, while they cover all electrical equipment, of which outside lighting is only a minor part
  - Electricity consumption is also lump unit that includes the whole consumption, also indoor lighting
  - Price of electricity is going up (7,5 RUB (0.1 EUR) now up to 8,5 next year kWh) (+13%). This is consistent with information found online for electricity price for businesses (globalpetrolprices.com):
    - Russia: 0,08 EUR/kWh
    - Estonia: 0,09 EUR/kWh
    - Finland: 0,12 EUR/kWh
    - Latvia: 0,13 EUR/kWh
    - Germany: 0,19 EUR/kWh
    - Denmark: 0,25 EUR/kWh
- In Russia, there are federal (national-wide), regional and municipal programs for introduction and uptake of LEDs.
- Situation related to adaptation of the tool in the St. Petersburg LUCIA pilot:
  - The pilot project budget is ready, and costs have been estimated, now waiting for procurement.
  - It would be interesting to compare with other LUCIA pilot projects.
- Social aspects – are they also "facts"? *Note: Hamburg is elaborating the related fact-sheet.*
- Lensvet is planning an electronic survey for the citizens in the beginning of the next year.
- Lensvet participated in a governmental energy forum in Moscow in September on energy (participants: cities, regions, different organizations. There was a questionnaire with a question on what the most important sphere for citizens in terms of city attractiveness is ->
  - Electricity 12 %
  - Heat supply 35 %
  - Water 8 %
  - Gas supply 8 %
  - Lighting of public spaces 35 %
- Who would use the tool and why?
  - Lensvet: proof of budget effectiveness

- University, state owned, support for new ideas and complementary interests

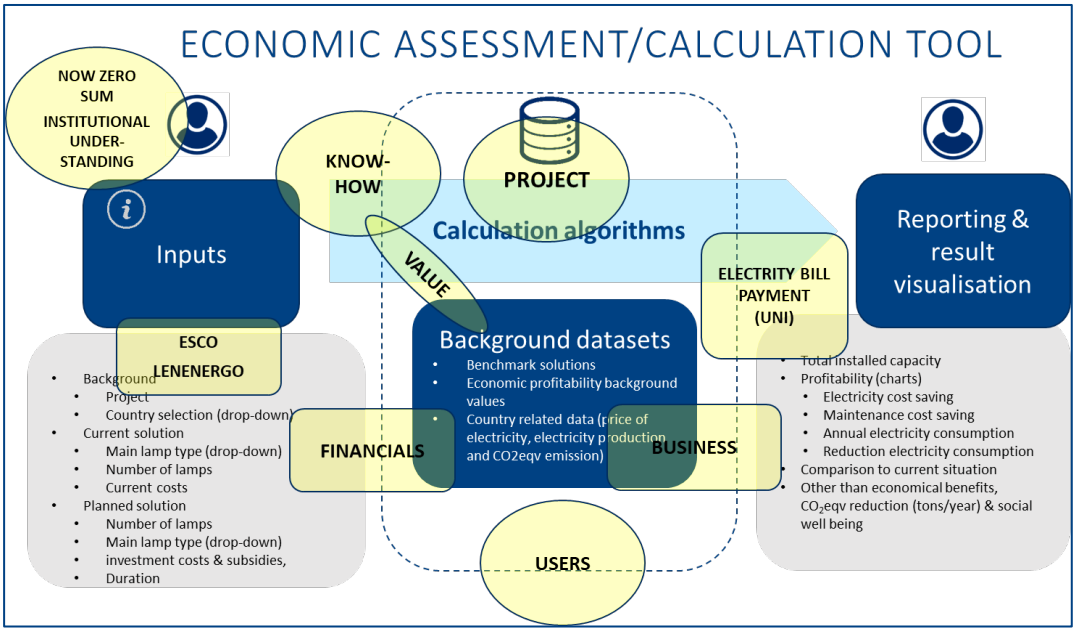


Figure 33: Participants of the workshops added their ideas and thoughts about the tool and possible business model (marked with yellow). Because of language issues and extra time needed for interpretation, this collaboration task replaced the negotiation game that was used in other workshops.

- Co-operation idea between the University and Lensvet (master studies, projects etc.) – University was presented: costs of maintenance, smart solutions, tackling e.g. the challenges of recruiting qualified specialists and managing the new kind of co-operation
- The University considers important also artistic lighting, including outdoor elements, and possibility to switch on and off.

Figure 34: Workshop in St. Petersburg. Photos by Topi Haapanen

5.1.5 HAMBURG WORKSHOP

Figure 35: Workshop materials ready and waiting for participants in Hamburg. Photo by Topi Haapanen.

Meeting title	HAMBURG PILOT SITE WORKSHOP Economy of the City Lighting - Environmental Opportunities and Challenges
Location	Patriotische Gesellschaft, Trostbrücke 4-6, 20457 Hamburg
Date	7 November 2019, 11:00 – 16:00

HAMBURG PILOT PROJECT PRESENTATION

https://www.lucia-project.eu/pilot-sites/hamburg-germany/

- Pilot Site Hamburg-Altona (Elbwanderweg/-radweg /Elbchaussee/Teufelsbrück), lighting for the public pathway
- Under consideration: responsibility vs. outsourced maintenance and knowledge
- In the beginning of 2000, the first decision on public lighting development to improve safety
    - Nowadays still missing sections.
    - Nocturnal ecology is an issue.
- Every morning between 6 - 10 am people using the ferries at Teufelsbrück, which serves 5 000 commuters, many arrive via a cycle pathway across the project area
- Illumination from October to March, the energy company will install new lamps from their current catalog, therefore ther is little space for innovation in procurement and costs are known
- Short term and long-term costs are interesting.
- General problem in Hamburg with regular complaints from citizens: lights are designed for cars on the street, not for pedestrians.

FACTSHEETS AND BENCHMARKING

REFERENCES FOR HAMBURG (SOURCE: EU EPC PROJECTS)

Altona, Germany	Kalmar, Sweden (2016)
270.000 (Hamburg 1,8 million)	Population: city centre 48.000 (whole municipality 64.000)
Budget approx. -	Investment costs: 165.000 € (no subsidies, EPC model)
Approx. 25 lamps	Number of streetlamps updated: 49 (average cost 3.367 €/lamp) — putting up a new lamp post in Hamburg : 6.500 - 7.500 eur
36W – 2x11W -> max 0,9 kW	Installed electric capacity: 6,5 kW (before, HPS) > 2,1 kW (after, LED)
	Annual consumption reduction: 65% (27.400 kWh > 9.000 kWh = 18.400 kWh)
	CO_2 reduction: 7,6 tons/year (2.421 kWh = 1 ton CO_2 vs. German grid?)
Current costs 150.000 light points	Electricity cost savings: 2.000 €/year (3.000 € > 1.000 €) — Payback time: 50 years (!?) — Avg. age 28 years — Avg. lifetime 50 years
9 eur. /year/inhabitant	Maintenance cost savings: 1.300 €/year
Hamburg ESCO incentives?	ESCO (Kalmar Energi) was going to renew the cables, offered EPC for whole renewal
	Kalmar conducted inventory of public lighting systems to address renovation needs

Figure 36: Reference data for the workshop

Discussion and comments from the participants, based on the drafts for the factsheets:

What happens in the smart urban lighting world?

- Disruption is what we need, not innovation.
- Maintenance costs are still not known.
- Calculations should focus on externalities.
- Transition from dark space to light is the problem.
- There are guidelines for the light planning that consider intensity of lighting.
- Legal instruments can be developed and adopted to different needs.
- Fulda as an example of city close to biosphere reservation – dark sky city – international guidelines to achieve certificate. First in Germany, Fulda got the status of International Dark Sky Community.
- Color temperature and intensity are significant.

To get different viewpoints for smart urban lighting projects, a negotiation game (see p. 6-7) was implemented. The workshop participants, who were divided into 7 different roles to reflect the imaginary approaches.

In the figure below you can see the division of opinions according to the given roles. The figure represents also the results from similar games implemented in Porvoo, Tallinn and Jūrmala, which did not differ from the viewpoints of Hamburg players.

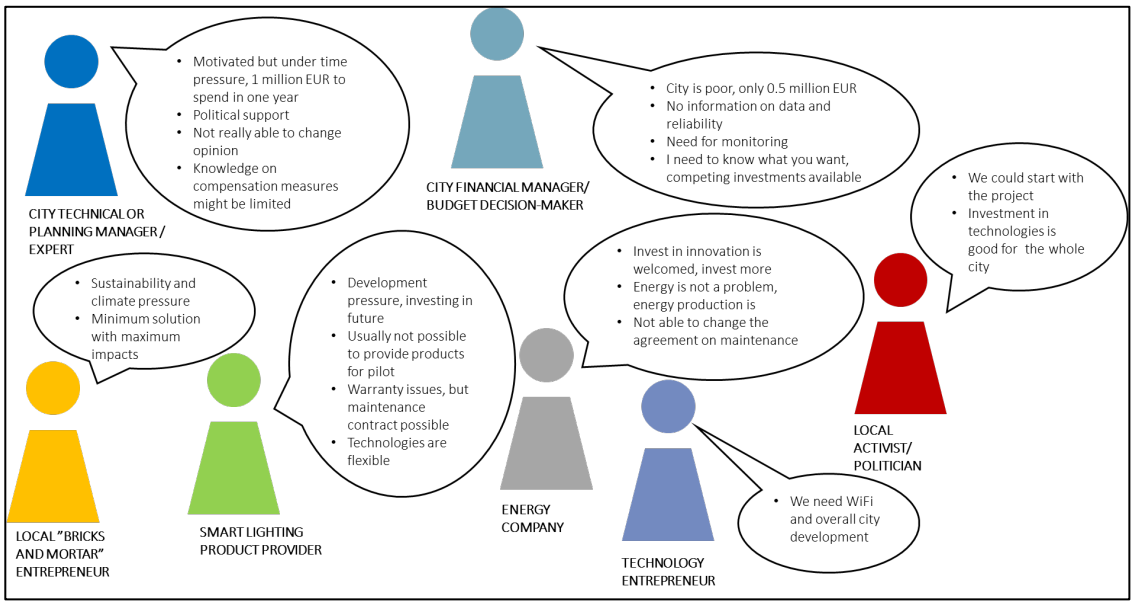


Figure 37: Different motivations of players in smart lighting projects

During the joint discussion after the game, the following thoughts were presented:

- Frozen thinking on economic calculations is not enough, other values and criteria need to be argued.
- Innovation pressure has direct and indirect economic impacts in future.
- There is a constant struggle between "easy project money" vs. "the long-term city economy".
- A compensation approach can also be applied in some cases.

CALCULATION TOOL

Discussion and comments from the participants:

- Adaptive lighting should be included.
- More information on technology should be included.
- The Saxonian electric company has developed a similar kind of tool, it should be benchmarked.

LIGHT POLLUTION IN CITIES & DARK SKY ZONES IN THE CITY

(Presentation of Dr. Andreas Hänel)

- Low-pressure sodium lamps have lower impact on nature.
- Complexity of the impacts is high.
- The lower the blue color amount, the better; monochromatic light is better for the nature.
- Light amount and intensity are the problem -> the lighting should be adaptive.
- Lighting trade in Fulda (shop windows vs. facade illumination).

- Ultrasound pollution from lamps should also be considered.

General questions for consideration, related to economics of adoption of smart urban lighting:

- What is preventing dissemination of smart lighting?
  - Literature says: "lack of appropriate municipal governance structures" (Polzin 2013)
  - EU agrees with International Energy Agency (OECD): support outsourcing in exchange for finance (EPC project)
  - Game theory: stakeholders do not incur in transaction costs if unsure of how benefits are shared post-investment
- Are there concrete bottlenecks at the project planning phase?
  - LUCIA hypothesis: experts need to produce better information for decision makers about economic benefits.
- Case of Hamburg
  - Inputs needed ideally vs. inputs available to make an assessment.
  - Who benefits / would benefit from what?
  - Users and relevant stakeholders? What is the appropriate level of public administration to steer this?

Figure 38: Hamburg workshop. Photos by Topi Haapanen.

5.2 MAIN FINDINGS AND CONCLUSIONS FROM THE WORKSHOPS

In each pilot city, the participants of the local expert workshops consisted of urban and infrastructure planners, local energy/electricity company representatives, other stakeholders, and hosts and project experts. The total number of participants reached 57 persons dealing with lighting.

As the main result of the workshops, the pilot sites with their specific features and goals became more familiar to the local parties, the content aspects of the factsheets to be elaborated became clearer, and the need and purpose of the calculation tool were sharpened.

The following table indicates some key findings that have evolved during the workshop series.

	PORVOO	TALLINN	JŪRMALA	ST. PETERSBURG	HAMBURG
PILOT CITY STARTING POINTS	The City owns the energy company.	The City does not own the energy company.	The City owns the energy company.	The City owns the lighting company.	The City owns the energy company (remunicipalization)[2]
	Roles of energy company and municipality – are there incentives between them? Who benefits from the cost savings? In order to support wider adoption of smart urban lighting in the Baltic Sea Region, which is the overall goal of LUCIA project, the workshop participants identified the necessity to start with the LUCIA pilot cities by scaling up applying the lessons learnt from the pilot to the whole city level.				
BENCHMARKS & FACTSHEETS	• Cases of tourism, art and their indirect effects • New technology – how long does it really take? • Ecologic aspects (e.g. bats)	• Lighting is more than light; light is a feeling • Technology is ready, but business models are still lacking	• Safety – surveillance – spying? • Look to the future: SDGs – with how many of them does the lighting match?	• How to deal with the technology risk? (e.g. LoRaWan network) • Already concrete plans to reach full LED by 2032.	• Adaptive lighting and avoiding light pollution are crucial. • Only efficiency gains are not enough but need to truly innovate.

[2] Since 2007, 170 municipalities have bought back their energy services (be it production or distribution), in a process called "remunicipalisation". Hamburg citizens approved its energy distribution remunicipalisation in a referendum in 2013, becoming subsequently the biggest German city to do so. It is argued that public ownership will promote a more sustainable strategy in the energy services management. See for example: https://www.worldfuturecouncil.org/energy-remunicipalisation-hamburg-buys-back-energy-grids/

<table>
<tr><td></td><td colspan="5">Data collection:
• It is important and rewarding to find, understand and analyze, from the point of view of economics, knowledge on smart urban lighting from implemented projects, previous programs and research.
• When thinking about the idea of supporting LUCIA pilots, you realize that the LUCIA pilots themselves are interesting cases and represent novel thinking, if compared with most of the cities and regions benchmarked.
Economic aspects:
• Projects are owned by one actor, but they affect many. The multi-stakeholder context is common to every pilot (energy company / lighting company / different city departments) and finding new cooperative ways to organize a project holds the key to win-win, larger economic benefits (and diverse financial delivery models).
• Big cities like St. Petersburg have existing plans for full LED transition with good adoption rate and availability of necessary funding.</td></tr>
<tr><td rowspan="2">CALCULATION TOOL</td><td>• Investment costs, but also increase of market value
• Quality and social impacts as important as economic ones</td><td>• Even if there is money available for a good idea, the projects are quite small in budget and the tool might help in rising their volumes</td><td>• Sustainable development goals could help in showcasing non-numeric indicators
• Focus: numbers + GIS – tool for planners</td><td>• Current situation information is missing at pilot level (but OK at City/Lensvet)
• It would be interesting to calculate the economic benefits from cooperating in new ways .</td><td>• Forecasting or measuring this project impact will not help with next project budget.
• Beyond calculations, we can change rules, make new legal instruments.</td></tr>
<tr><td colspan="5">According to feedback from the participants, there was a shift of requirements and needs from numeric to qualitative and multi-functional directions:

CALCULATION ⇨ ASSESSMENT ⇨ PLANNING

• In the beginning of the project, the significance and coverage of the tool was regarded not so big, but during the process it became more and more interesting.
• The tool was initially envisioned for technical designers, but LUCIA pilots are doing well without the tool (given there is a budget).
• Perhaps the main challenge lies on the economic risks evolving from novel technologies applied.
• Energy savings are obvious for clients at least in Finland, but maintenance savings from remote monitoring of lamps are more unknown and, thus more relevant for decision making.
• Pilot cities have wished for an overall planning solution guiding everything (from technology to assessing social equity with GIS) – but this is beyond the scope of FCG's assignment and not strictly economic aspects.
• Yet, the tool can be further developed later. The main LUCIA focus - people first, only then technology and money – supports the idea that also non-numeric indicators would be considered when justifying new smart urban lighting projects.</td></tr>
</table>

6 CALCULATION TOOL

Task: to design and implement a calculation tool to support economic evaluation and analysis of the energy efficient urban lighting.

The results from the information collection phase provided a good basis to adapt other indicator and investment calculation tools that FCG had already used or developed for similar projects. The original tool must be simple enough and visually attractive for users, but also present relevant results in easily adaptable format. The goal with the tool is to help technical experts provide answers to decision-makers' questions about the economic benefits of smart and energy efficient lighting solutions.

Phases:

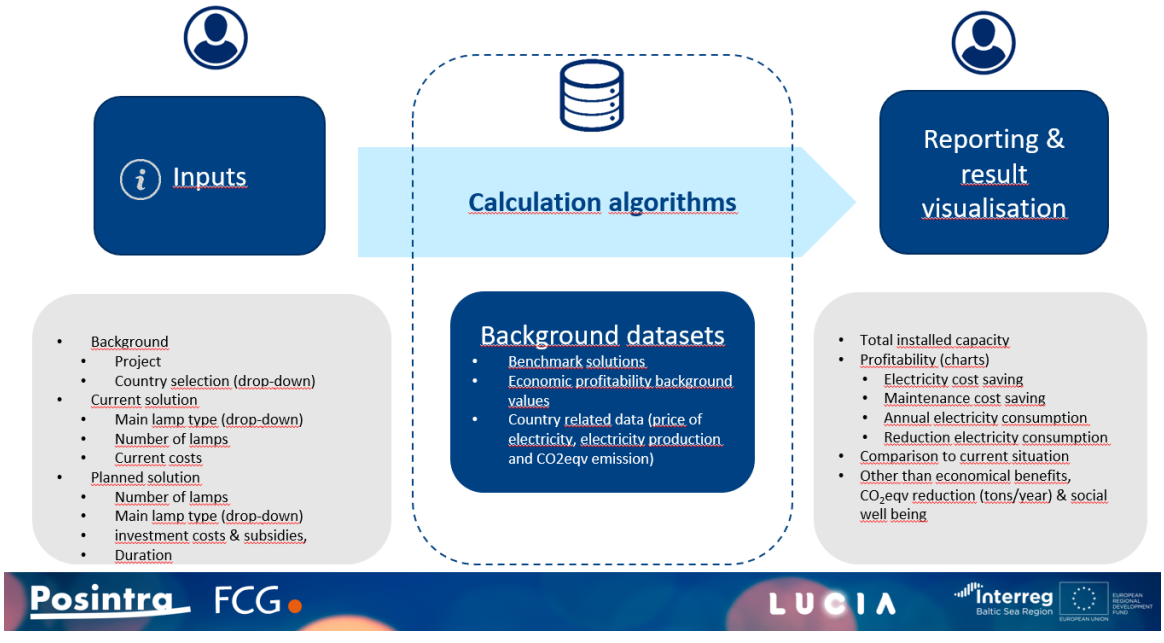
- Benchmark: similar tools for smart lighting planning

  We benchmarked institutional calculation tools from the Baltic Sea area to avoid relying on commercial solutions that may include vendor or regional bias.

  For example, the Finnish Government Innovation Agency Motiva's VALTTI tool can be found online (in Finnish: https://valaistustieto.fi/laskuri/) and it is used when there is available information on the project price. The tool takes into consideration life cycle costs in investment, energy and maintenance. It complies with EU directives for LCC assessment as it is open to the public and developed in cooperation with the sector stakeholders and companies.

- Initial planning (input-output)

  The calculation proposed in the first economic workshop in Porvoo was as follows:



- Feedback from users

A mock-up of the tool was presented to workshop participants, explaining what the required inputs were. All pilot managers expressed their concern about the lack of available input data. Thus, the idea of short checklists and questionnaires was introduced in the design of the tool, to help demonstrate qualitative, non-quantifiable economic, ecologic, social and cultural benefits.

- Testing and comments from partners
  The test version was shared to all LUCIA partners at the beginning of 2020 with the goal of presenting the received feedback at the next partner meeting (Copenhagen, end of March 2020).

- Finalization and final presentation
  If needed, an iterated version will be released in cooperation with the partners looking forward to using the tool in upcoming projects.

7 CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- Budget constraints and lack of knowledge about project finance (either market-based delivery modes or through alternative business models) continue to affect most cities in the Baltic Region. Based on our workshops, the only exception was St. Petersburg, where participants from the Public Lighting Company Lensvet commented that they did not see budget as a problem in relation to accelerating smart urban lighting retrofits.

- However, this might not be the only economic factor slowing down the diffusion of smart lighting in the Baltic region. There are some other reasons why cities might legitimately choose to wait:

    - On the lighting technology side, uncertainty about the life cycle costs of new technology are paired with a considerable yearly rate for products' price lowering, making it reasonable to wait for next year's product offerings while more detailed research about LCC is produced.

    - Concerning new business models, the roll out of 5G technology has been much slower than initially promised by the industry, adding uncertainty to the existance of a supporting network for new services. While IoT and data integration continues to evolve quickly, there is a sense that maybe the "right solution to unlock platform economy benefits" is just around the corner, making it sensile to delay investments.

- An integrated approach to the economics of smart city projects in general, not only smart lighting, was apparently missing from all the pilot cities (at least not in used to guide the pilot). Municipal operations are still strongly divided into departments and silos: the pilot partners had difficulties in bringing participants to the economic workshops from outside the engineering or land and park planning circles.

- Any smart urban lighting project requires many stakeholders: the different municipal departments, maybe a financier, a platform technology provider, and additional service providers. The lack of trust among them, the uncertainty in the procurement and investment process and the lack of knowledge about contractual agreements are significant barriers to the diffusion of smart urban lighting projects. Stakeholders do not incur in the required transaction costs prior to the investment decision if there are not incentives to compensate for the lack of knowledge about how the benefits will be shared post- investment.

- The lack of stablished practices for green and innovative procurement, where economic benefits would be defined against a sustainable development strategy, further disincentive the municipalities to include multifunctional solutions, new business models or an overall economic approach to these projects.

- In most of the pilot projects the already ongoing planning or procurement process considered "smart lighting" as equal to "LED lighting with some level of automatic control" and thus negated the possibility to test or support the development of new business models.

- Another hurdle in the way of energy efficient retrofits is the lack of data about the electricity consumption. Arguments about the savings of smart lighting investments require an ongoing measurement and control of the city's energy economics.

- New research linking artificial light to the decline of insects was published during the realization of this report. The effects of insect reduction or extinction are considered catastrophic to ecosystems. Considering this, the "smartest" and most economically beneficial lighting would be to simply minimize overall urban lighting: just turn off the lights.

Recommendations for further supporting the goals of the LUCIA project from an economic perspective:

- Interreg funds earmarked for supporting innovation should not be used in pre-existing projects that have been long paused, either because implementation money was missing or because there was a certain controversy preventing their approval. We have observed this situation in some pilot cities and the problem is that the window of opportunity opened by the Interreg special situation goes into making up for previous budget cuts (in the case of funding), or for blessing with the EU brand a contested situation. Pre-existing projects inherit a certain context (e.g. answering to a lighting need in a certain area, a personal sense of ownership over the project) that limits the degrees of freedom of the pilot and makes it much more difficult to innovate at the process level within key activities (e.g. cross-silo municipal strategic cooperation, procurement practices).

- Beyond cooperation among cities in the Baltic Sea region, different types of local stakeholders **within** one location should be included as official pilot project partners in order to drive innovation. In relation to the economics of smart urban lighting projects, piloting new solutions would greatly benefit from inputs besides the different municipal functions. We would recommend partners from at least five other sectors: (i) electricity generation and distribution (e.g. local ESCO), (ii) financial services, (iii) stablished lighting technology products providers, (iv) challengers from the startup community and (v) the local academic and research institutions.

- The developed assessment and calculation tool should be tested by the LUCIA pilot sites. Feedback on its usability and impact as a decision support tool can be used to both further develop it and to reframe the problem of municipal decision making for sustainable infrastructure investments under deep uncertainty.

- Further facilitation and consulting efforts should be directed towards leading roles or more strategic units in the municipal organization (e.g. mayor's executive office or board of directors) with the aim of bridging silos and creating a shared understanding about the economics of smart city transformations and investments.

- To achieve economically successful smart lighting projects (or innovative procurements of smart lighting) cities must agree beforehand, internally and with the EU (possible under the upcoming Green New Deal Investment program), what are the criteria to consider the goals are reached.

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