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SUMMARY REPORT: LOCAL EXPERT WORKSHOPS – ECONOMIC ASPECTS OF SMART URBAN LIGHTING

• Porvoo • Tallinn • Jūrmala • St. Petersburg • Hamburg

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Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

CONTENTS

Figure 1: Waiting and ready for the workshop launch. Photo by Topi Haapanen.

1 SUMMARY

This report deals with the series of Local Expert Workshops, organised 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 workshops explored the **economic aspects** of energy efficient urban lighting and provided participants up-to-date information about the topic. Interactive sessions were organised during October-November 2019 in five pilot cities of the project: Porvoo, (Finland), Tallinn (Estonia), Jūrmala (Latvia), St. Petersburg (Russia), and Hamburg (Germany). Together with the local LUCIA project managers, the Finnish Posintra Ltd. – one of the project partners from Porvoo - and the subcontracted expert company FCG Design and Engineering Ltd. from Finland, were responsible for implementation and facilitation of the workshops.

2 BACKGROUND – ECONOMIC ANALYSIS OF SMART URBAN LIGHTING

The Local Expert Workshops were part of the LUCIA project implementation and its WP2 GoA 2.2, co-ordinated by Posintra Ltd, Finland.

LUCIA ?	= LUCIA - Lighting the Baltic Sea Region, Cities accelerate the deployment of sustainable and smart urban lighting solutions (a 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 realisation 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). 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,
- elaboration of factsheets on the topic,
- development of a calculation tool to support design and evaluation of smart lighting investments, and
- facilitation of local expert workshops that support the other tasks above.

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

Topi Haapanen 	Jaana Myllyluoma 	Jan Tvrdý 	Carlos Lamuela 
WP2 GoA 2.2. co-ordination	FCG's overall assignment, workshops	Calculation tool	Banchmarking 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 experts, responsible for the economic analysis, inc. facilitation of the workshops (e-mails for gaining further information)

The produced information package and implemented economic analysis tools are aimed at increase knowledge of the planners and decision-makers and help them to promote and adapt innovative lighting solutions.

3 WHAT WERE THE WORKSHOPS ALL ABOUT?

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 organised during October-November 2019 in five pilot cities:

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

Figure 3: 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 platforms for local discussions, ideas and perhaps some worries. An important question was to identify what would be the most relevant information from economic point of fiew to support the cities in the pilot site realisation - 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.

CONTENT AND TOPICS OF THE WORKSHOPS

Economic aspects were the main 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 worskshop, 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 smat urban lighting in the Baltic (overall goal of LUCIA project)
- Factsheets
  - FCG's task is to draft 4-5 factssheets demonsrating 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.

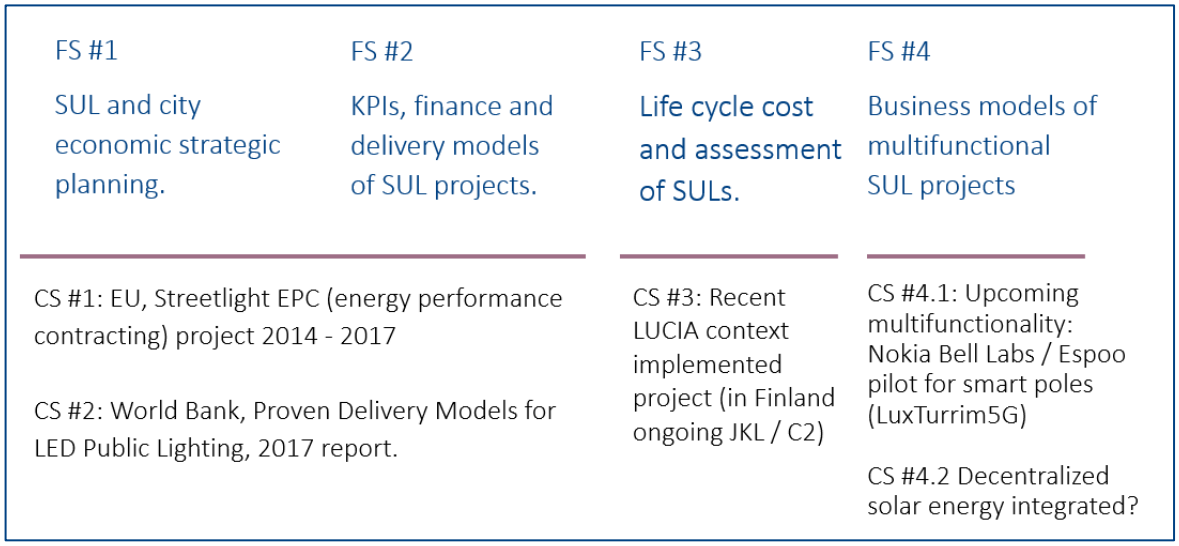

Figure 4: Proposed factsheets (FS) and benchmarking case studies (CS). KPI = Key Performance Indicator.

- 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, inc. 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 entreprneur (small	- You would like the new urban lighting to include an additional technology feature because

and local / big and international)	A) Your business idea need 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 assuptions 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

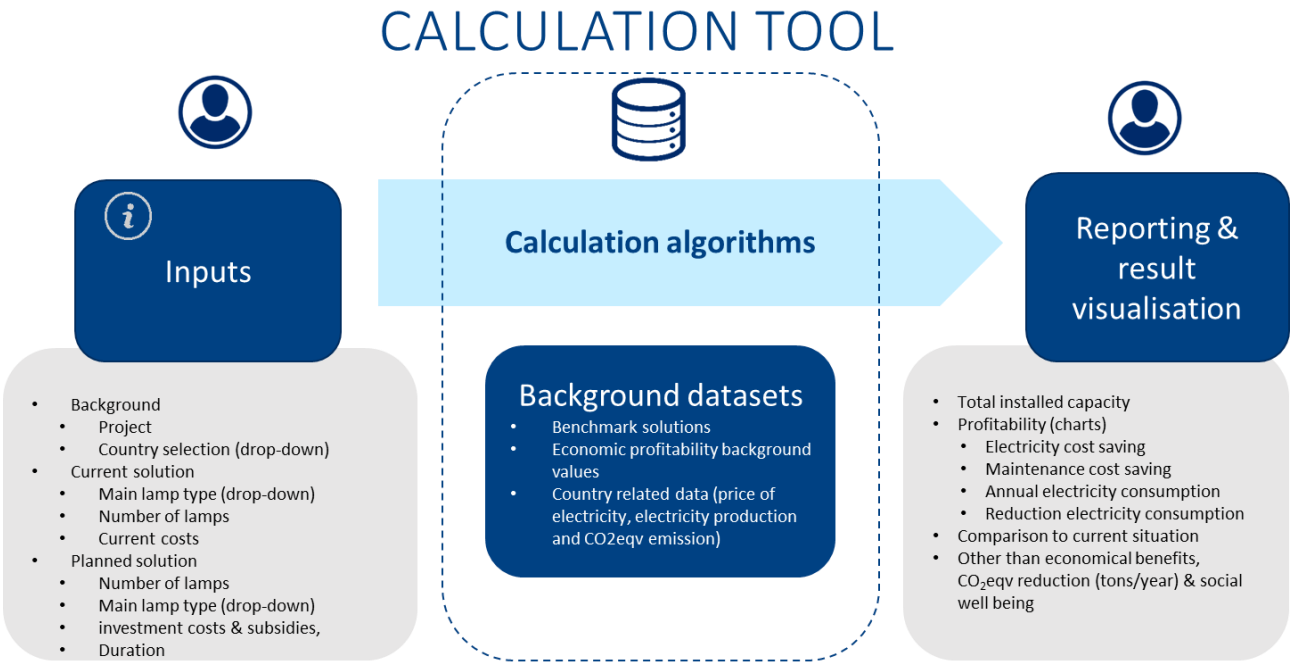

Figure 5: Draft structure of the calculation tool to be developed

4 WORKSHOP SERIES

4.1 PORVOO WORKSHOP

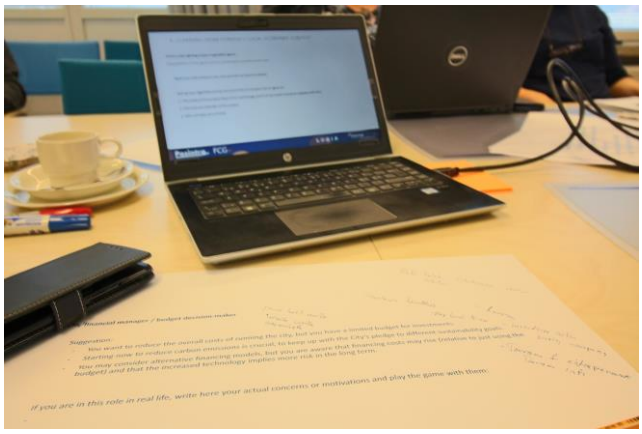

Figure 6: Workshop tools in Porvoo. Photo by Topi Haapanen.

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

PROGRAMME

8.30 Starting remarks, Posintra
- *Participants introductions*

8.45 Porvoo smart urban lighting pilot project presentation, City of Porvoo
- *Current status and unique aspects*

9.00 Benchmarking smart urban lighting economic aspects, FCG
- *Presentation, FCG: preliminary international benchmarks / factsheets*
- *Thematic discussion: best practices in new smart urban lighting investments, case Porvoo + LUCIA*

9.30 Learning from Porvoo + LUCIA: the pilot economic context
- *A closer look at: roles, responsibilities, budget, bottlenecks, decision making (game preparation, 15 min)*
- *Negotiation games in 2 or 3 groups (30 min)*

10:15 Coffee break

10.30 User-friendly and goal-oriented smart urban lighting investment project economic assessment tool
- *A closer look at the how (usability) and what for (the problem it solves) of the assessment tool.*

11.15 Wrap-up: final remarks, steps forward

12.00 End of the workshop

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, stabilisation 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 centre 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 amount 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 take into account 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 7: 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.
- Who benefits from the savings, city or the energy company, is not clear.
- 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-iceing 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. street lights). 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)
- Taking into account ethnographic groups and equality, e.g. better connectivity of suburban areas to the city centre
- 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

  - Cant the tool be used for optimisation of maintenance
  - Is there a need for monitoring of 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 8: Porvoo workshop. Photos by Topi Haapanen

4.2 TALLINN WORKSHOP

Figure 9: 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

PROGRAMME

12.00 Starting remarks, Posintra
- *Participants introductions*

12.30 Tallinn smart urban lighting pilot project presentation, City of Tallinn (presentation in Estonian language)
- *The current status, unique aspects*

12.45 Benchmarking smart urban lighting economic aspects, FCG
- *Presentation, FCG: preliminary international benchmarks / factsheets*
- *Thematic discussion: best practices in new smart urban lighting investments, case Tallinn + LUCIA*

13.15 Learning from Tallinn + LUCIA: the pilot economic context
- *A closer look at: roles, responsibilities, budget, bottlenecks, decision making*
- *Time to play the negotiation game!*

14:00 Coffee break

14.15 User-friendly and goal-oriented smart urban lighting investment project economic assessment tool, co-creation
- *A closer look at the how (usability) and what for (the problem it solves) of the assessment tool.*

15.00 Wrap-up: final remarks, steps forward

15.45 End of the workshop

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 decrease 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: 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 WiFi 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 10: Some benchmarking takeways 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 some kind of 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 11: Tallinn workshop. Photos by Topi Haapanen.

4.3 JŪRMALA WORKSHOP

Figure 12: 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

PROGRAMME

12.00 Starting remarks, Posintra
- *Participants introductions*

12.30 Jūrmala smart urban lighting pilot project presentation
- *The current status, unique aspects*

12.45 Benchmarking smart urban lighting economic aspects, FCG
- *Presentation, FCG: preliminary international benchmarks / factsheets*
- *Thematic discussion: best practices in new smart urban lighting investments, case Jūrmala + LUCIA*

13.15 Learning from Jūrmala + LUCIA: the pilot economic context
- *A closer look at: roles, responsibilities, budget, bottlenecks, decision making*
- *Time to play the negotiation game!*

14:00 Coffee break

14.15 User-friendly and goal-oriented smart urban lighting investment project economic assessment tool
- *A closer look at the how (usability) and what for (the problem it solves) of the assessment tool.*

15.00 Wrap-up: final remarks, steps forward

15.45 End of the workshop

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 Kwh
- 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

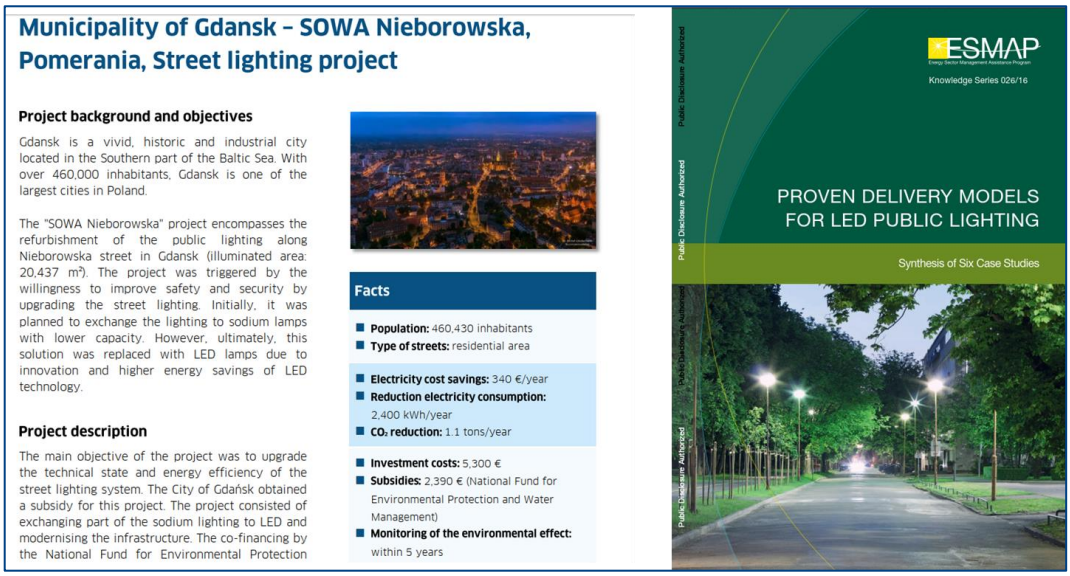

Figure 13: Benchmarking example discussed in Jürmala

Discussion and comments form 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 14: 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)
- What is there beyond the numbers?
- Testing at least among the Lucia people?
- Jūrmala has a GIS system under development – could it be connected to the tool?
- Different layers
    - Social impact assessment extension
    - Environmental impact assessment

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

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 algo-rithms
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 compari-son	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:
  - 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 15: Workshop in Jūrmala. Photos by Topi Haapanen and Jaana Myllyluoma.

4.4 ST. PETERSBURG WORKSHOP

Figure 16: 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

PROGRAMME

10.00 **St. Petersburg LUCIA pilot project presentation, Peter The Great University**
The current status, unique aspects

10.15 **Benchmarking smart urban lighting economic aspects, FCG**
Presentation, FCG: preliminary international benchmarks / factsheets
- What happens in the urban city lighting world?
- Upcoming technologies for multifunctional smart urban lighting?

11:00 **Learning from St. Petersburg + LUCIA: the pilot economic context**
Discussion: What we know now about the economic context at the St. Petersburg pilot and city lighting in general?
A closer look at: factors and relations affecting the technological and economic trade-offs: Influence map exercise with quick assessment of economic benefits of smart urban lighting projects

12:15 ***Coffee break***

12:45 **Economic assessment/calculation tool for smart urban lighting projects**
A closer look at the how (usability) and what for (problems/challenges it should solve) of the tool

13:45 **Wrap-up: final remarks, steps forward**

14:00 **End of the workshop**

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 have to consult 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 (fibre optics) for controlling the lighting
    - Video monitoring
    - WiFi 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), actually, 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 are 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). Summa summarum, 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 17: Lensvet web page, http://www.lensvet.spb.ru/ (pages in Russian, use automatic Google translation RUS-ENG)

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 analysed – GIS (division: blocks, parks, streets)

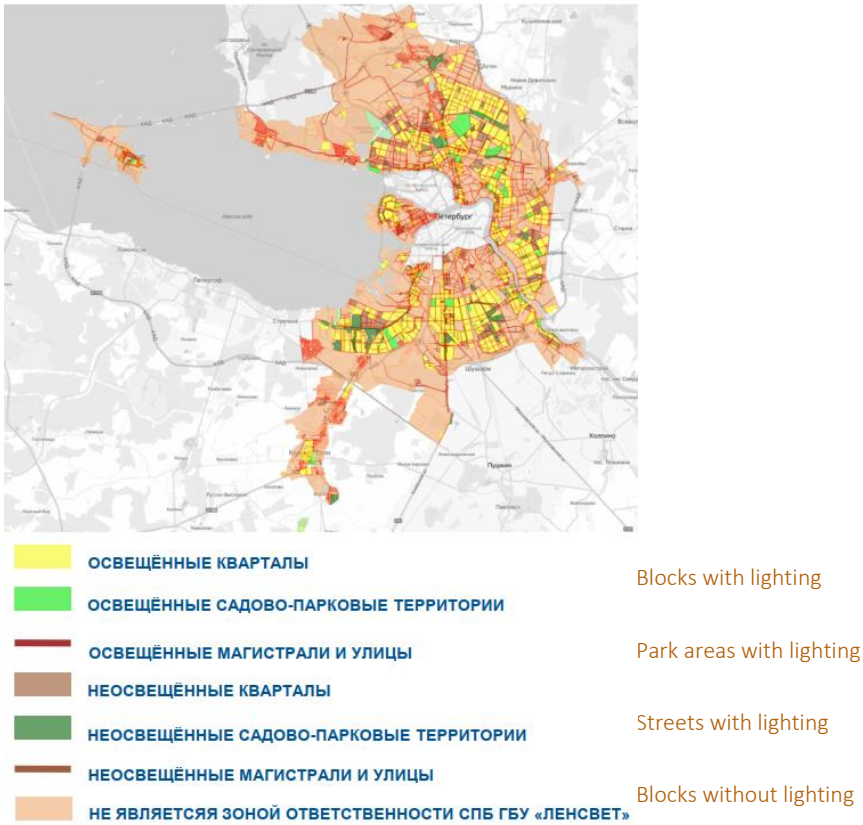

Figure 18: Status of 11 mapped districts

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

  - Karpovka Promenade with river embankment.

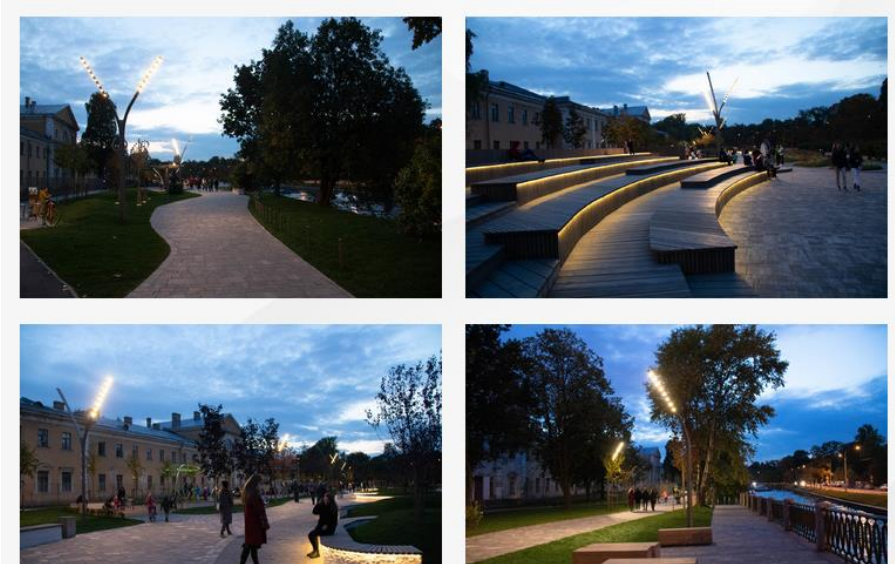

Figure 19: Karpovka promenade

- 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: automatisation, digitalisation, 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 taking into account 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 take into account 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?

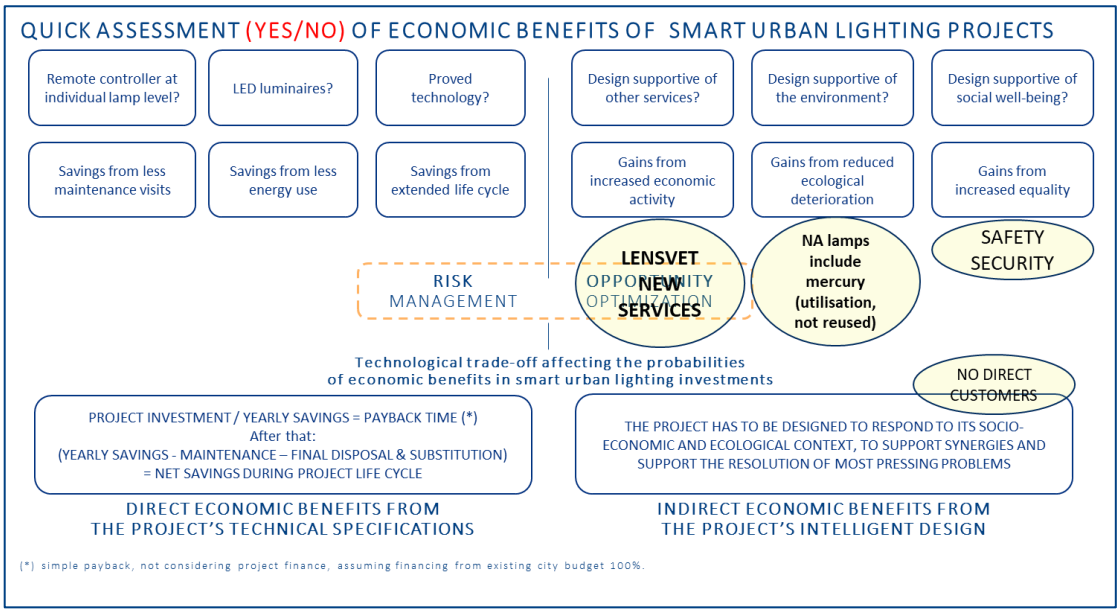

Figure 20: Influence map: "What are the factors affecting the economics of your pilot project?" Additions by workshop participants marked with yellow background

- 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 organisation that collects the lamps and extracts valuable components
  - Lensvet pays them for 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 also 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 organisations. There was a questionnaire with a question on what is the most important sphere for citizens in terms of city attractiveness ->
  - 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

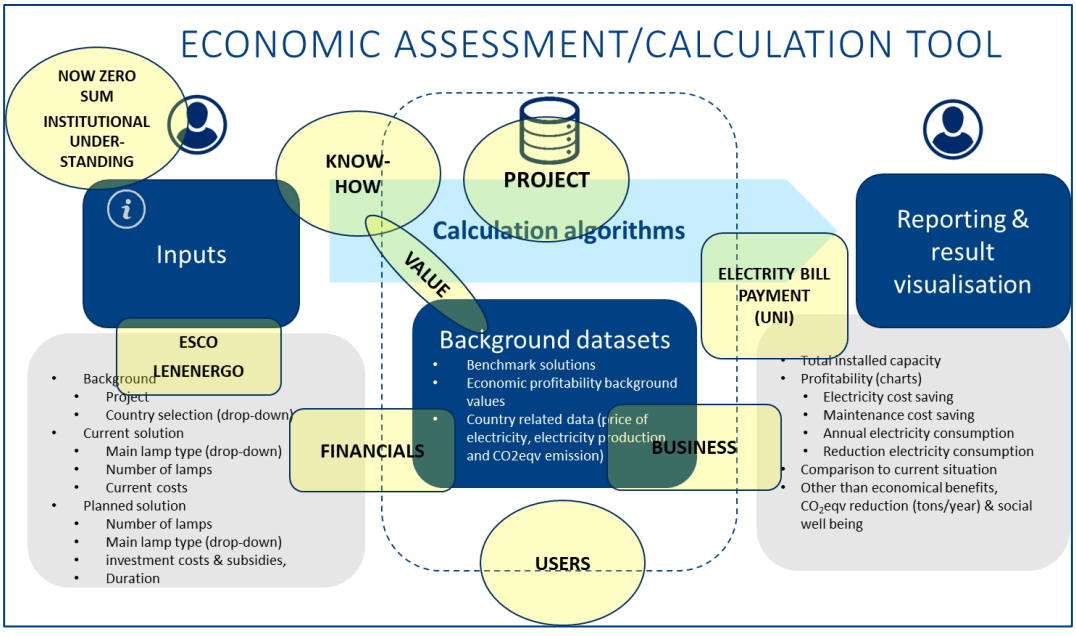

Figure 21: Participants of the workshops added their ideas and thoughts about the tool and possible business model (marked with yellow). Because of language issues and extra time needed for interpretation, this collaboration task replaced the negotiation game that was used in other workshops.

- 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 22: Workshop in St. Petersburg. Photos by Topi Haapanen

4.5 HAMBURG WORKSHOP

Figure 23: 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

PROGRAMME

11:00	Arrival and Registration	
11:15	Welcome to the Workshop	
	An overview about the LUCIA project	**Heike Bunte & Topi Haapanen**
	Introduction of the participants	
11:30	The Local Expert Workshops	
	Series of the workshops	**Topi Haapanen**
	What have we discovered so far?	**Jan Tvrdý**
11:45	LUCIA Pilot Site in Hamburg	
	Short introduction about the LUCIA pilot in Hamburg	**Heike Bunte**
12:00	What Happens in the World? - International Benchmarks	
	Best practises and facts from the economic point of view	**Carlos Lamuela**
12:30	***Discussion – Round 1***	
	Different Viewpoints in Lighting Projects	**Carlos Lamuela + participants**
	An interactive negotiation game	
13:00	Lunch Break	
14:00	Support for the Future	
	Development of the assessment tool for economic evaluation of the smart urban lighting	**Jan Tvrdý**
14:30	Light Pollution in Cities	
	Challenges between marketing, public safety and environment	**Dr. Andreas Hänel**
15:00	***Discussion - Round 2***	**Heike Bunte + participants**
	Dark Sky Zones in the City – chances and risks	
15:30	***Discussion - Round 3***	**Topi Haapanen + participants**
	Wrap-up Discussion and Closing Remarks	
16:00	End of the Workshop	

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.
- Illumination from October to March, the energy company will install, but there is ~~no~~ space for innovation, costs are known
- Short term and long-term costs are interesting.
- General problem in Hamburg with regular complaints from citizens: lights are directed on the street, not on 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 24: Reference data for the workshop

Discussion and comments from the participants:

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 take into account 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.
- Colour 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.

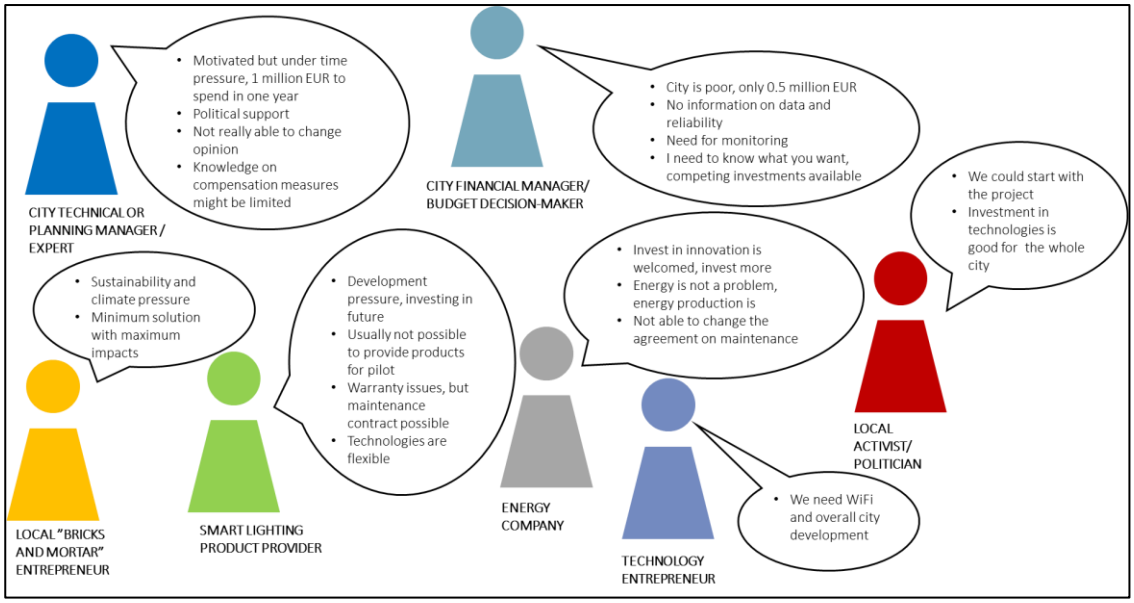

Figure 25: Different motivations of players in smart lighting projects

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 solution should 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 colour 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 taken into account.

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 26: Hamburg workshop. Photos by Topi Haapanen.

5 MAIN FINDINGS AND CONCLUSIONS

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 speficic 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 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 brought 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. In any case, during the Hamburg workshop it became apparent that cooperation between the energy company and planning activity undertaken in the City-state's boroughs is very weak (e.g., apparently the energy company was invited to the LUCIA workshop, but did not participate). 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 analyse, 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 realise 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 good idea, the projects are quite low budgeted 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 helpt with next project budget.
• Beyond calculations, we can change rules, make new legal instruments.</td></tr>
<tr><td colspan="5">Accorcing 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 taken into account when justifying new smart urban lighting projects.</td></tr>
</table>