GUIDELINE ON FINDING A SUITABLE FINANCING MODEL FOR PUBLIC LIGHTING INVESTMENT

Deliverable D.T2.3.1 Baseline inventory

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DYNAMIC LIGHT

Project description

The Dynamic Light project aims to demonstrate the importance of providing light under a variety of circumstances and to examine who uses lighting at what time and for how long. The project explores strategies for introducing energy-efficient, dynamic lighting in urban areas and identifies the steps required to translate strategies into action, from the initial idea through the analysis, geographic information system data mining, strategy development, financial modelling, procurement process, implementation and evaluation. These strategies are intended to facilitate investment in pilot and demonstration projects that bolster acceptance of energy-efficient lighting among end-users and urban planners by improving the quality of dynamic light and adapting it to social needs. The project examines the implementation of public lighting under conditions typical of European municipalities.

Consortium

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BSC, Poslovno podporni center d.o.o. Kranj	SL	Ernst-Moritz-Arndt-Universität Greifswald	DE
PORSENNA o.p.s.	CZ	SWARCO V.S.M. GmbH	DE
Međimurska energetska agencija d.o.o.	CR	Deutsche Lichttechnische Gesellschaft e.V.	DE
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GUIDELINE ON FINDING A SUITABLE FINANCING MODEL FOR PUBLIC LIGHTING INVESTMENT: DELIVERABLE D.T2.3.1 - BASELINE INVENTORY

Upgrading street lighting infrastructure to improve energy efficiency is an investment that reaps rewards in the form of substantial energy savings and reductions in carbon dioxide emissions. It is also highly cost-effective and has a short payback period. In spite of these advantages, the infrastructure in many European countries has not been upgraded. The objective of this assessment is to identify the obstacles to infrastructure improvement in these areas. We survey public and private actors to examine stakeholder knowledge and experience relevant to financing models for energy efficiency upgrades of street lighting. Based on the survey results, we provide recommendations for the next stages of our tasks for the Dynamic Light project.

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Executive summary

Investment in energy efficiency upgrades significantly reduces energy costs and carbon dioxide emissions. It is also highly cost-effective and has a short payback period. However, many areas of Central Europe have not taken measures to improve lighting infrastructure. The objective of this assessment is to examine the reasons for low upgrade rates in these areas. The report identifies the key stakeholders responsible for providing street lighting, as well as those involved in street lighting asset ownership, operation, maintenance and investment. We survey public and private actors to examine barriers to investment and assess stakeholder knowledge and experience regarding financing models for energy efficiency upgrades of street lighting. Based on the survey results, we provide recommendations for the next stages of the Dynamic Light project.

Key stakeholders in energy efficiency street lighting investment

From the stakeholder survey responses, we conclude that, in the majority of Central European countries, municipalities are legally responsible for providing street lighting. Often, the legal responsibility can be transferred under a concession agreement. In some countries, it is also possible to transfer the legal responsibility under energy performance contracts and through public-private partnerships. In a few countries, private capital may not be used to upgrade public street lighting; this is clearly problematic, as it means that other finances must be leveraged for these upgrades.

We also conclude that the fragmented structure of the street lighting supply chain often poses a split-incentive barrier for upgrades. The countries covered by our surveys have many different practices in place for ownership, maintenance, operation and upgrades of street lighting assets. The results of the survey show that often the legal responsibility to ensure proper public street lighting, ownership of street lighting assets, maintenance and operation, as well as the actual investment decisions, are divided between several stakeholders. This creates a split-incentive problem, e.g., those who have to upgrade street lighting do not accrue the benefits of this investment.

Barriers to energy-efficient street lighting investment

Survey responses showed that the strongest barriers to investment in energy-efficient street lighting upgrades were financial and economic obstacles (namely, insufficient financial resources). In addition to the shortage of financial resources, municipalities would like to see more support from the national and regional public budget. Small municipalities are also more likely than larger municipalities to struggle with small budgets.

Barriers related to policy and awareness were given lower importance than the financial barriers. The highest barrier identified in the policy category was ‘poor enforcement for energy efficiency policies, even though these exist’, and the highest barrier in the awareness category was unfamiliarity with and/or reluctance towards new contractual and financing mechanisms. The barriers related to implementation capacity were rated lower than the financial barriers but higher than policy and awareness barriers.

The perceived relative importance of different barriers varies across respondent groups. For instance, researchers, energy service contractors and energy service companies, and energy and development agencies most often believe that the lack of skills and experience in municipalities’ implementation of street lighting projects presents high or high-medium barriers, whereas municipalities themselves perceive these barriers as less significant. In addition, municipalities see upfront costs as a high barrier and do not think that energy cost savings are low due to low energy prices. By contrast, energy service contractors and energy service companies do not perceive upfront costs as high but do see a larger problem in low energy cost savings due to low energy prices. These examples show the asymmetry in these actors’ perception of the relative significance of various barriers and demonstrate their different experiences.

Table 1 shows three barriers in each barrier category that were identified as most significant by the survey respondents. It is important to note that the table includes the average perception of barriers among all respondents. Therefore, it does not reflect the variation in the perceived relative importance of different barriers across respondent groups. Of all barriers listed in the table, the most significant (average response: high-medium) are not enough own financial resources, lack of skills and experience by municipalities, not enough national or regional public funding, and lack of human resources in the municipality.

Table 1. Top three barriers to energy-efficient street lighting investment by the barrier group

Barrier group			
Financial and economic	Policies and frameworks	Awareness, access to information and past experiences	Implementation capacity and procedures
• Not enough own financial resources • Not enough national or regional public funding • High up-front investment cost	• Lack of guidance on the national level • Poor enforcement of energy efficiency policies • Energy efficiency is not a priority on the municipal level	• Unfamiliarity and reluctance to new contractual and financing mechanisms • Lack of awareness of potential funding sources • Lack of awareness of potential energy savings	• Lack of skills and experience by municipalities • Lack of human resources in the municipality • Project complexity incl. multiple stakeholders

Awareness and experience on financing energy efficiency in street lighting

Furthermore, we identify a gap in knowledge of existing public and private funding sources. Many respondents from municipalities do not have experience and are not aware of typical funding sources from the EU and national budgets, even though they often do not have sufficient capital of their own to finance certain projects. Therefore, there is a need to raise awareness about possible public and private funding sources among municipalities and other actors who may invest in energy-efficient street lighting.

We also recognise a gap in knowledge of possible financing models for leveraging more private finance. This is critically important because the public budget cannot provide the finances to realise the full energy efficiency potential of the public sector, given that there are also other important economic, social and environmental priorities.

Introduction of our future work

In response to the challenges identified in the previous section, one of our next deliverables will focus on the inventory of possible public and private funding sources for street lighting upgrades. In another deliverable, we will provide an overview of existing financing models, such as innovative self-financing models, debt-financing models, third-party financing and public-private partnerships. Based on these two deliverables, we will prepare a final deliverable presenting a set of recommendations for decision-makers on finding and implementing a suitable financing model.

Finally, we plan to disseminate these deliverables and recommendations to municipalities and other actors, in particular those in the private sector, which could be involved in financing energy efficiency upgrades of street lighting. This is critical in order to close the gap between the public and private sectors and raise awareness of relevant circumstances, priorities and obstacles.

Abbreviations

CO_2	Carbon dioxide
EBRD	European Bank for Reconstruction and Development
EIB	European Investment Bank
ELENA	European Local Energy Assistance
ERDF	European Regional Development Fund
EPC	Energy performance contracting
ESC	Energy service contractor
ESCO	Energy service company
EU	European Commission
JESSICA	Joint European Support for Sustainable Investment
KfW	Kreditanstalt für Wiederaufbau
LED	Light-emitting diode
PPP	Public-private partnership
SPV	Special purpose vehicle

1. Introduction

Investment in the upgrade of urban street lighting infrastructure saves energy and reduces carbon dioxide (CO_2) emissions by up to 80% (C40 Cities 2011). It is also very cost-efficient and has a short payback period (EIB 2013). In spite of these arguments, a large share of the infrastructure in many countries of Central Europe still requires renovation. High upfront investment costs and budget constraints on infrastructure owners (often municipalities) are frequently cited as explanations for the lack of progress. To overcome this obstacle, creative business models are required to attract additional investors.

The Dynamic Light project aims to promote dynamic, intelligent and energy efficient urban lighting. Task 2.3 of the project requires the identification of suitable finance models for this infrastructure. The project focusses on the countries of Central Europe, namely Austria, Croatia, the Czech Republic, Germany, Hungary, Italy, Poland, Slovakia, and Slovenia. It is supported by the Interreg Central Europe platform.

The present report addresses the requirements of task 2.3. It aims to provide an inventory of knowledge and experience among relevant actors (including those in the public sector) in financing energy efficiency upgrades of street lighting. The results are based on online surveys of these stakeholders.

Following this introduction, section 2 of the report describes the methodology of our survey data collection. Sections 3 to 6 present the results of our surveys, focussing on the barriers hindering various stakeholders from upgrading street lighting energy efficiency and assessing their familiarity and experience with the use of different funding sources and financing schemes. Section 7 discusses the implications of the results for the next stages of our tasks within the Dynamic Light project.

2. Methodology

Our research was conducted in three stages. First, we examined the status quo in knowledge of financing mechanisms for energy efficient street lighting in Central Europe. For this, we collected data from up-to-date internet sources. In particular, we identified projects that conducted similar studies in the past and reviewed their source documentation. We also gathered other information available in the public domain, e.g., from reports, articles, interviews, and internet websites. The results of this inventory are presented in Annex 1.

In the second stage, we conducted a survey of our project partners. Our survey included questions on the characterisation of currently installed street lighting infrastructure, its electricity consumption, as well as relevant technologies and practices. The survey also asked for information on the current and past investment, best practices, associated challenges and stakeholders involved in the ownership, maintenance, operation and upgrade of the infrastructure. The survey questionnaire used in the second stage is reproduced in Annex 2.

In the third stage, we improved the questionnaire used in stage 2 and sent it out to stakeholders that have an interest in street lighting and are not in our consortium. This stage was not required for the project, but because the information obtained from our literature search and the first survey did not yield comprehensive information, we decided to include this stage in our research.

In stage 3, we identified the contacts of 34 associations of municipalities, cities, towns and counties in Central Europe and asked them to forward our survey to their members. We also identified the contacts of approximately 300 stakeholders from the priority group for our task and sent them invitations to fill out the survey. These stakeholders included representatives of regional or national energy agencies, product manufacturers, engineering service providers, energy services companies, researchers and consultants. We

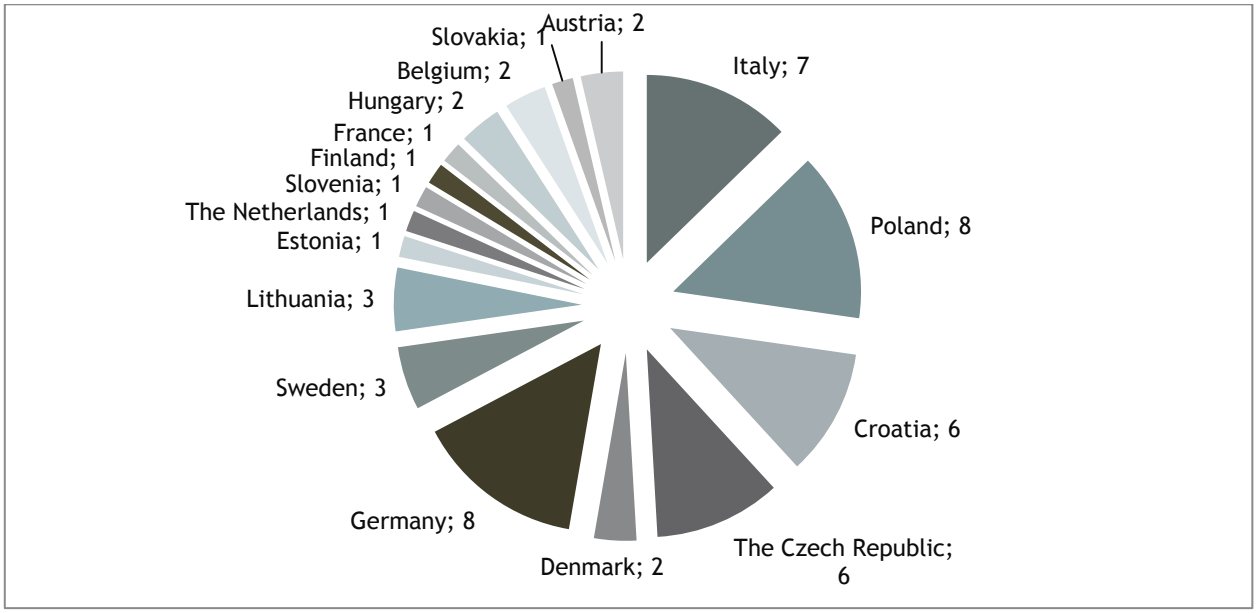
also sent out the survey through the mailing list Climate-L.[1] The survey questionnaire used in stage 3 is attached in Annex 3.

Our survey was answered by 59 respondents. Of these, 55 respondents were from the EU Member States and were representatives of:

- 15 municipalities and two associations of municipalities (the Association of Cities of the Republic of Croatia and the Association of Polish Cities);
- four regional energy and development agencies, including the North-West Croatia Regional Energy Agency, the Energy Agency for Southeast Sweden, the APE FVG Energy Management Agency of Friuli Venezia Giulia of Italy, and AGIRE Energy Agency of the Province of Mantova of Italy;
- five lighting product manufactures;
- three energy service contractors (ESCs)[2] and/or energy service companies (ESCOs)[3] and/or their affiliates;
- 21 researchers and consultants;
- and six consumers, including homeowner associations.

Figure 1 presents the distribution of EU respondents by country. The figure shows that the majority of respondents were from the countries of Central Europe, including the project partner countries.

Figure 1: The distribution of respondents by country



Source: Survey results.

[1] Please see http://sdg.iisd.org/sdg-update/about-the-sdg-update-newsletter/ for information on Climate-L.

[2] Energy service contracting refers to outsourcing of a part or all energy-related services from the owner of street lighting to a contractor.

[3] Energy Performance Contracts (EPCs) are used to finance municipal infrastructure projects by private partner, usually an Energy Service Company (ESCO) through energy savings.

We would like to note that the respondents do not constitute a representative sample. As a result, the results of our analysis should be treated with caution. Furthermore, answers survey respondents answered questions to the best of their knowledge. Therefore, these answers may not necessarily reflect the objective situation in the countries surveyed. Because this paper analyses these responses, it, too, may not represent the objective situation.

3. Stakeholder analysis

In order to analyse the barriers and opportunities for investment in energy-efficient upgrades of street lighting, it is important to understand which stakeholders are involved. Analysis in this section is presented as a series of tables. To present large amounts of information in the most compact and efficient way, we colour-coded the responses of different stakeholder groups according to Table 2 below.

Table 2: Colour coding used in this chapter to present survey responses from different stakeholder groups

Municipalities	Manufacturers	Researchers / consultancies	Energy or development agencies	ESCs/ESCOs	Consumers
●	●	●	●	●	●

3.1. Actors legally responsible for proper street lighting

The fragmented structure of the street lighting supply chain (i.e., the fact that the organisation responsible for ensuring proper street lighting may not be the one that actually owns, operates, and maintains street lighting infrastructure) may pose a barrier for its upgrade. In many EU countries, local (municipal) governments are legally responsible for providing street lighting. Therefore, the municipality must manage the financing of proper street lighting in order to ensure that it complies with requirements, including technical and safety norms and standards. For instance, high-pressure mercury lamps (HPM) were to be phased out completely by 2015 and medium efficient metal halide lamps by 2017, according to the Ecodesign Directive (2009/125/EC).

We started our questionnaire by asking who bears the legal responsibility for proper street lighting in the jurisdictions to which each respondent belonged. Table 3 presents a summary of answers provided by survey respondents. Given that street lighting is a public service, the parties with legal responsibility are almost always municipalities. As a result, municipalities should answer this question correctly. The table illustrates, however, that answers often varied, depending on the stakeholder group to which respondents belong, and the responses of other groups often do not coincide with those of the municipalities. This means that other stakeholder groups, including researchers, are not always aware of who is actually responsible for the ownership, operation and maintenance of street lighting and therefore the depth of the problem.

In general, municipalities are legally responsible for proper street lighting. Finnish, German, Swedish and Austrian respondents also noted that the owners of private streets with public access rights are also legally responsible for proper street lighting. Among the respondents selecting the ‘Other’ category, one homeowner from Lithuania reported that street lighting in his/her district is funded by the homeowner association that is legally responsible for proper street lighting. However, this responsibility is later transferred to the municipality. The other municipal respondent from the Czech Republic reported that only federal, municipal or regional governments have this responsibility and that it can be ‘transferred’ between these three levels of the government.

Table 3: Which actor is legally responsible for proper street lighting: survey results by respondent group

Respondents / Country	Total respondents	Federal government	Municipal government	Companies owned by municipality	Private or partially private companies	Other
Austria	● ●	●	● ●			
Belgium	● ●	●	● ●	●		
Croatia	● ● ● ● ● ●		● ● ● ● ●	●		
Denmark	● ●	● ●	●	●		
Estonia	●		●			
Finland	●					
France	●		●			
Germany	● ● ● ● ● ●	●	● ● ● ● ● ● ●			
Hungary	● ●		● ●			
Italy	● ● ● ● ● ● ● ●	●	● ● ● ● ●	●	● ●	
Lithuania	● ● ●		● ●			●
Netherlands	●	●	●			
Poland	● ● ● ● ● ● ● ●	● ●	● ● ● ● ●	●	●	
Slovakia	●					
Slovenia	●		●			
Sweden	● ● ●	● ● ●				
Czech Republic	● ● ● ● ● ●	●	● ● ● ●		●	●

● Municipalities ● Manufacturers ● Researchers / consultancies ● Energy or development agencies ● ESCs/ESCOs ● Consumers

Source: Survey results.

Note: The table summarises survey responses to the specific question, which respondents answered to the best of their knowledge. The results shown may not accurately represent the actual situation in the survey countries.. The responses also do not necessarily reflect the views of the authors.

3.2. Possibility of transferring legal responsibility to other actors

The respondents indicated that in some countries, it is possible to transfer to other actors the legal responsibility for proper lighting. Table 4 presents the survey respondents' understanding of the circumstances under which a transfer is possible. In many countries, legal responsibility may be transferred under a concession agreement.[4] In some countries, it is possible to transfer legal responsibility under energy performance contracts (EPC) and in public-private partnerships (PPPs).[5]

[4] The concession agreement stipulates that the concessionaire has the legal responsibility for certain functions or processes in accordance with agreed terms. For example, such agreements may allow energy supply companies to use public assets if a community (municipality) receives a concession levy in return (Wold Bank online at https://ppp.worldbank.org/).

[5] A public-private partnership is a long-term contractual relationship between a private party and a government entity. The agreement governs the provision of a public asset or service for which the private party bears significant risk and management responsibility, and remuneration is based on performance [World Bank online at http://ppp.worldbank.org/public-private-partnership/overview/what-are-public-private-partnerships].

Table 4: Possibility of transferring the legal responsibility for proper lighting to another actor: survey results by respondent group

Country	Respondent group	Under which circumstances may the legal responsibility to ensure proper lighting be transferred to another actor
Austria	Manufacturers	Upon installation, street lighting systems are transferred to municipalities and maintained by municipal companies.
	Municipalities	In privately owned areas.
Belgium	Researchers	In contracts with the involvement of ESCOs.
Croatia	Agencies	In PPP contracts. In contracts with the involvement of ESCOs.
	Municipalities	By concession. In contract about maintenance of street lighting.
Denmark	Manufacturers	Via tenders.
Estonia	Municipalities	Though public procurement.
Finland	Municipalities	If city planning changes the ownership of areas or streets. If a city spreads out so that government streets (highways) become part of the city.
France	Researchers	The legal responsibility always remains with the municipality.
Germany	ESCs/ESCOs	The legal responsibility always remains with the municipality.
	Manufacturers	The legal responsibility stays with the governmental organization, but the acting role may be transferred to a contractor based on a contract which ensures that all legal rules, standards, etc. will be maintained.
Italy	Agencies	In contracts with the involvement of ESCOs.
	Municipalities	By concession.
Lithuania	Consumers	Upon installation of the street lighting system it will be transferred to the municipality and maintained by a municipal company.
	Municipalities	In order improve street lightning network.
	Researchers	In PPP contracts. In contracts with the involvement of ESCOs.
Poland	Municipalities	None because it is the responsibility of local governments.
	Researchers	The legal responsibility always stays by the municipal authorities.
Slovenia	Agencies	In Slovenia, every municipality has a concession agreement or something similar for the maintenance and upgrade of the street lightning.
Sweden	Consumer	None, unless road is private.
	Agencies	There is no legislation that demands streetlights, it is "voluntary" in Sweden, but if you install streetlights it should follow recommendations from e.g. the Swedish traffic administration.
	Manufacturers	If a municipality chooses to sell off its lighting system.
Czech Republic	ESCs/ESCOs	In case of a contract ensuring the appropriate light is delivered.
	Municipalities	The legal responsibility cannot be transferred to a private company. Only federal, municipal or regional government has this duty. It can be "transferred" between these three subjects.
	Researchers	Street lighting is legally part of streets/highways and thus it is owned by owners of streets - mostly municipalities, or regional districts/counties, or state (main roads, highways).

Source: Survey results.

3.3. Actors owning street lighting

Although municipal governments are usually legally responsible for proper street lighting, they are not necessarily the owners of the infrastructure. This fact may cause a split incentive barrier when those who have to upgrade street lighting do not accrue the benefits of this investment.

Table 5 summarises the survey responses on the ownership of street lighting infrastructure. According to the respondents, street lighting is usually owned by the municipal government or by companies that are owned by municipalities. In Italy, Lithuania, Finland, Poland and the Czech Republic, municipalities reported that private or partially private companies may also own street lighting.

One municipality responded that, in Poland, the municipality itself is responsible for providing proper street lighting but the street lighting infrastructure may be owned by electricity distribution companies. Therefore, while the municipality must provide proper street lighting and invest in its upgrade, electrical distribution companies will benefit from this investment.

The ownership of street lighting could also be mixed. For instance, in a few cases in Croatia, the owners of public street lighting are both local municipalities and the Croatian National Electricity Company (HEP Ltd.). The local municipalities are the owners of luminaires, while HEP Ltd. owns the public lighting pillars. This also represents an organisational barrier to street lighting upgrade, as municipalities have greater interest in the upgrade while both actors are involved in this process.

Table 5: Who owns street lighting: survey results by respondent group

Respondents / Country	Total respondents	Federal government	Municipal government	Companies owned by municipality	Private or partially private companies	Other
Austria	● ●		●			
Belgium	● ●	●	● ●	●		
Croatia	● ● ● ● ● ●		● ● ● ● ● ●	●		
Denmark	● ●	●	●	●		
Estonia	●		●			
Finland	●	●	●	●	●	
France	●			●		
Germany	● ● ● ● ● ●	●	● ● ● ● ● ●	● ●	● ●	
Hungary	● ●		● ●		●	
Italy	● ● ● ● ● ● ● ●		● ● ● ● ●		● ● ●	
Lithuania	● ● ●		● ●		●	
Netherlands	●					
Poland	● ● ● ● ● ● ● ●	●	● ● ● ● ● ●	● ●	● ● ●	● ●
Slovakia	●					
Slovenia	●		●			
Sweden	● ● ●	● ● ●	● ● ●	● ●		
Czech Republic	● ● ● ● ● ●	● ●	● ● ● ● ● ●	●	● ●	●

● Municipalities ● Manufacturers ● Researchers / consultancies ● Energy or development agencies ● ESCs/ESCOs ● Consumers

Source: Survey results.

Note: The table summarises survey responses to the specific question, which respondents answered to the best of their knowledge. The results shown may not accurately represent the actual situation in the survey countries. The responses also do not necessarily reflect the views of the authors.

3.4. Possibility of private investment in public street lighting infrastructure

One of the survey questions asked whether there can be private investment in street lighting infrastructure owned by public actors. The municipalities responding to the survey reported that such investment is possible in Germany, Poland, Italy and Croatia under EPC contracts and in PPPs; in the Czech Republic, Estonia and Sweden under EPC contracts; and France in PPPs. According to the responses of municipalities and regional energy and development agencies, investment of this kind is not possible in Lithuania, Austria, Finland or Slovenia. The latter clearly hinders the leveraging of private investment into energy-efficiency upgrades of street lighting.

3.5. Actors maintaining street lighting

Table 6 presents survey responses to a question on who maintains street lighting. The maintenance services include the day-to-day replacement and repair of street lighting infrastructure components.

According to the respondents, street lighting is often maintained by in-house staff of municipalities. However, it is also fairly common for municipalities to issue maintenance tenders to public, semi-public or private companies. These companies may do the maintenance work themselves or issue tenders to sub-contractors.

Table 6: Who maintains street lighting: survey results by respondent group

Respondents / Country	Total respondents	Federal government	Municipal government	Companies owned by municipality	Private or partially private companies	Other
Austria	● ●			● ●	●	
Belgium	● ●	●	● ●	● ●		
Croatia	● ● ● ● ● ●		● ● ●	●	● ● ●	
Denmark	● ●		●	●	●	
Estonia	●		●		●	
Finland	●		●	●	●	
France	●			●		
Germany	● ● ● ● ● ●	● ●	● ● ● ● ● ●	● ● ● ● ● ●	● ● ● ●	●
Hungary	● ●		● ●		●	
Italy	● ● ● ● ● ● ●		● ● ● ●	● ●	● ● ●	
Lithuania	● ● ●		●	●	●	
Netherlands	●					
Poland	● ● ● ● ● ● ●		● ● ● ●	●	● ● ●	● ●
Slovakia	●				●	
Slovenia	●				●	
Sweden	● ● ●	● ●	● ●	● ● ●	● ●	
Czech Republic	● ● ● ● ● ●	● ●	● ● ● ● ●	● ● ● ● ●	● ● ●	

● Municipalities ● Manufacturers ● Researchers / consultancies ● Energy or development agencies ● ESCs/ESCOs ● Consumers

Source: Survey results.

Note: The table summarises survey responses to the specific question, which respondents answered to the best of their knowledge. The results shown may not accurately represent the actual situation in the survey countries. The responses also do not necessarily reflect the views of the authors.

3.6. Actors operating street lighting

We also asked survey respondents who operates street lighting. As with maintenance, daily street lighting operation, which may also include the purchase of electricity, is either carried out by in-house municipal staff or contracted out to municipality-owned companies or private or semi-private companies (Table 7). Whenever the operation contracts are short-term, they do not provide incentives to improve street lighting infrastructure.

For instance, according to a respondent from the town of Čakovec (Croatia), the town has responsibility for proper lighting and ownership of street lighting. The town sub-contracted a private company, KABEL-MONT Ltd., for street lighting maintenance services. Elektra, the publicly owned electricity supplier, operates urban lighting in all areas of the Međjimurje County, including the administrative area of Čakovec.

Table 7: Who operates street lighting: survey results by respondent group

Respondents / Country	Total respondents	Federal government	Municipal government	Companies owned by municipality	Private or partially private companies	Other
Austria	● ●			●		
Belgium	● ●	●	● ●	● ●	●	
Croatia	● ● ● ● ● ●		● ● ●	● ● ● ●	●	
Denmark	● ●			●		
Estonia	●		●		●	
Finland	●		●	●	●	●
France	●			●		
Germany	● ● ● ● ● ●	● ●	● ● ●	● ● ● ● ● ●	● ● ●	●
Hungary	● ●		● ●		●	
Italy	● ● ● ● ● ● ●		● ● ●	●	● ● ●	
Lithuania	● ● ●		●	●	●	
Netherlands	●					
Poland	● ● ● ● ● ● ●		● ● ● ●	● ●	● ● ●	● ●
Slovakia	●				●	
Slovenia	●				●	
Sweden	● ● ●	● ●	● ●	● ● ●	● ● ●	
Czech Republic	● ● ● ● ● ●	● ●	● ● ● ●	● ● ● ●	● ● ●	

● Municipalities ● Manufacturers ● Researchers / consultancies ● Energy or development agencies ● ESCs/ESCOs ● Consumers

Source: Survey results.

Note: The table summarises survey responses to the specific question, which respondents answered to the best of their knowledge. The results shown may not accurately represent the actual situation in the survey countries. The responses also do not necessarily reflect the views of the authors.

3.7. Actors upgrading street lighting

Finally, Table 8 summarises the answers from survey respondents on who upgrades street lighting. According to respondents, the upgrade could be implemented by municipalities' in-house staff or outsourced to municipally-owned companies or private or semi-private companies.

Table 8: Who upgrades street lighting: survey results by respondent group

Respondents / Country	Total respondents	Federal government	Municipal government	Companies owned by municipality	Private or partially private companies	Other
Austria	● ●			●		●
Belgium	● ●	●	● ●	● ●	●	
Croatia	● ● ● ● ● ●		● ● ● ● ● ●	●	●	
Denmark	● ●			●	●	
Estonia	●		●			
Finland	●		●	●	●	●
France	●			●		
Germany	● ● ● ● ● ●	●	● ● ● ● ● ●	● ● ● ● ● ●	● ● ●	●
Hungary	● ●		●		●	
Italy	● ● ● ● ● ● ●		● ● ● ●	●	● ● ●	
Lithuania	● ● ●		●	●	●	●
Netherlands	●					
Poland	● ● ● ● ● ● ●	●	● ● ● ● ●	● ●	● ● ●	● ●
Slovakia	●				●	
Slovenia	●				●	
Sweden	● ● ●	● ●	● ●	● ● ●	● ● ●	
Czech Republic	● ● ● ● ● ●	● ●	● ● ● ●	● ● ● ● ●	● ● ●	● ●

● Municipalities ● Manufacturers ● Researchers / consultancies ● Energy or development agencies ● ESCs/ESCOs ● Consumers

Source: Survey results.

Note: The table summarises survey responses to the specific question, which respondents answered to the best of their knowledge. The results shown may not accurately represent the actual situation in the survey countries. The responses also do not necessarily reflect the views of the authors.

There are thousands of municipalities in Europe, some with a population of less than 100 people. Municipalities of this size face a number of barriers to investment in street lighting upgrades. In particular, the scale of such projects is not large enough to attract private investors. In this case, project bundling may be a solution.

Few survey respondents demonstrated knowledge of opportunities for project bundling, and even fewer could provide examples of its use. Of the 55 European survey participants, the only respondents that reported use of this practice were one Lithuanian municipality, which cited one such project in the city of Panevezys; one researcher from the Czech Republic, which reported a project in the town of Litomyšl; and one Croatian regional energy agency, which referred to a bundling project among 62 municipalities from the counties of Zagreb and Krapina-Zagorje.

4. Barriers to investment in street lighting upgrades

In order to better understand why street lighting energy efficiency is upgraded at such low rates in Central Europe, survey participants were asked about the barriers to investment that they face. Altogether, we identified 31 barriers that can be classified into four categories: economic and financial barriers; barriers related to policies and frameworks; barriers related to awareness, access to information and past experience; and barriers related to implementation capacity and procedures. We asked our respondents to

rate each barrier as 'high', 'medium-high', 'medium', 'medium-low' and 'low'. After collecting the results, we assigned each rate a numeric value from 5 to 1, respectively.

For each barrier, we have provided an analysis of the average answers for the whole sample, as well as the average and the most frequent answer (mode) by stakeholder group. In some cases, we colour-coded the results of our analysis for better visual presentation. Figure 2 summarises the colour coding of these figures. Fields coloured red indicate stakeholder groups perceiving certain barriers as the biggest hurdles. Green fields reflect perceptions that a barrier has minor significance, while yellow fields indicate moderate significance.

Figure 2: Possible ratings for barriers used in questionnaire 2

High	Medium-High	Medium	Medium-Low	Low
5,0	4,0	3,0	2,0	1,0

4.1. Financial and economic barriers

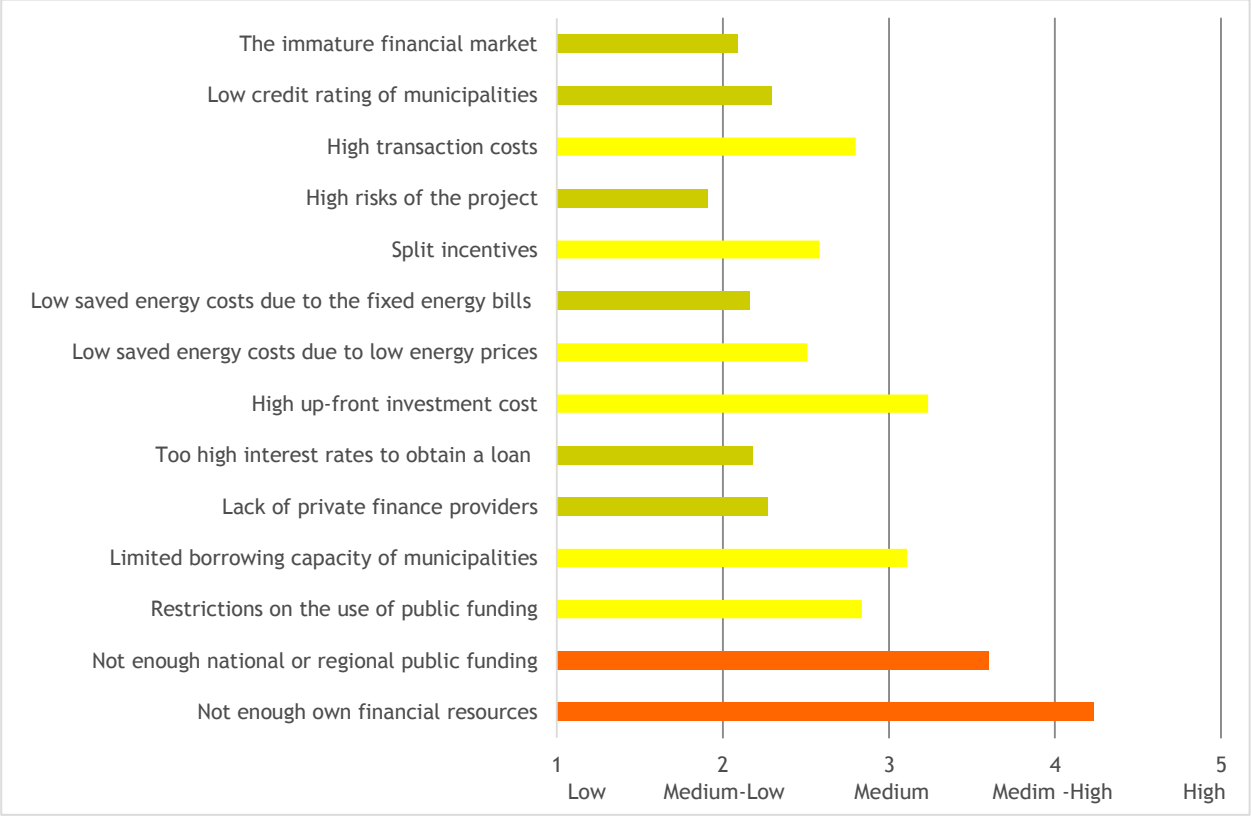
First, the respondents were asked to rank their perception of financial and economic barriers, such as:

- Not enough own financial resources for owners of street lighting, e.g., municipalities or utilities;
- Not enough national or regional public funding;
- Restrictions on the use of public funding;
- Limited borrowing capacity of municipalities;
- Lack of private finance providers, e.g., commercial banks, energy service companies, contractors, institutional investors, etc.;
- Too high interest rates to obtain a loan from public or commercial banks;
- High up-front investment cost;
- Low saved energy costs due to low energy prices, e.g., energy price fluctuations, national currency exchange rate fluctuations, political instability, etc.;
- Low saved energy costs due to the fixed energy bills which do not depend on energy consumption
- Split incentives between street lighting infrastructure ownership and upgrade, e.g., when street lighting is owned by an actor who has low incentives to reduce electricity consumption whereas saved energy costs are accrued by another actor;
- High risks of the project;
- High transaction costs e.g., the costs of the project preparation, tendering, and negotiation;
- Low credit rating of municipalities;
- The immature financial market, e.g., low availability of financial products and services;
- Other barriers.

Figure 3 presents the average rating for barriers related to economic and financial aspects of street lighting upgrades; the average is calculated for the entire survey sample. As Figure 3 shows, the highest barriers perceived by all respondents are the insufficiency of financial resources among owners of street lighting infrastructure and the shortage of national and regional funding. The barriers evaluated as

moderate are high upfront investment costs, high transaction costs, split incentives between street lighting infrastructure ownership and upgrade, limited borrowing capacity of municipalities, restrictions on the use of public funding, and low saved energy costs due to low energy prices.

Figure 3: The average rating of barriers related to economic and financial aspects of street lighting upgrades



Source: Survey results.

Table 9 presents the average perception of the financial and economic barriers by stakeholder category. The table shows clear differences in the relative importance attributed to the barriers by the different groups. Our analysis yields a number of interesting insights.

First, the table illustrates that stakeholder groups perceive the weight of the barriers differently. On average, municipalities and their associations, as well as energy and development agencies, energy service contractors and energy service companies attach greater weight to the barriers than do manufacturers, researchers or consumers. It is also interesting that researchers and consultants attribute less significance to the barriers than do all other actors, except for consumers.

Second, the table makes it clear that different stakeholder groups perceive different barriers as the most significant. According to the average ratings submitted by municipalities, regional energy and development agencies, and ESC/ESCOs, the most important barrier is the insufficiency of financial resources among the owners of street lighting and the shortage of national and regional public funding. However, manufacturers believe high upfront investment costs and split incentives between street lighting infrastructure ownership and upgrade are equally significant.

The table also shows variation between public- and private-sector perception of barriers. Municipalities regard upfront costs as high and do not think that saved energy costs are low due to low energy prices.

The reverse is true for ESCs/ESCOs, which do not perceive upfront cost as high but see a larger problem in low saved energy costs due to low energy prices. If saved energy costs are low or uncertain, there is a risk that the projects will not pay back the initial investment, labour costs and the business margin.

Table 9: The average rating for barriers related to economic and financial aspects of street lighting upgrades (by stakeholder group)

Respondents / Barriers	Municipalities	Energy or development agencies	Research / consultancy	Manufacturers	ESCs / ESCOs	Consumers
Not enough own financial resources for owners of street lighting	4.5	4.6	4.0	4.0	4.3	4.2
Not enough national or regional public funding	4.1	4.0	3.4	3.4	3.3	3.0
Restrictions on the use of public funding	3.1	2.6	3.1	2.0	2.7	2.2
Limited borrowing capacity of municipalities	3.2	3.6	3.4	2.6	3.0	1.8
Lack of private finance providers	2.5	2.0	2.3	3.0	2.7	1.2
Too high interest rates to obtain a loan from public or commercial banks	2.4	2.2	2.4	2.0	1.3	1.3
High up-front investment cost	3.2	3.2	3.3	4.2	2.0	3.0
Low saved energy costs due to low energy prices	2.5	1.8	2.7	3.2	3.3	1.5
Low saved energy costs due to the fixed energy bills which do not depend on energy consumption	2.2	1.6	2.6	2.2	1.7	1.3
Split incentives between street lighting infrastructure ownership and upgrade	2.6	1.4	2.6	3.4	3.0	2.5
High risks of the project	2.1	1.8	2.2	1.6	1.0	1.3
High transaction costs	2.8	2.8	2.9	3.0	2.7	2.3
Low credit rating of municipalities	2.4	1.4	2.6	1.8	2.7	1.8
The immature financial market	2.0	2.6	2.0	2.8	0.7	2.2

Source: Survey results.

Table 10 presents the most frequent perception of barriers having economic and financial nature by stakeholder group. A comparison of Table 9 and Table 10 indicates that the average rating and the most frequent ratings for barriers may not coincide.

Table 10: The most frequent rating for barriers related to economic and financial aspects of street lighting upgrades (by stakeholder group)

Respondents / Barriers	Municipalities	Energy or development agencies	Research / consultancy	Manufacturers	ESCs / ESCOs	Consumers
Not enough own financial resources for owners of street lighting	5.0	5.0	5.0	3.0	4.0	5.0
Not enough national or regional public funding	5.0	5.0	4.0	3.0	#N/A	4.0
Restrictions on the use of public funding	3.0	1.0	4.0	#N/A	#N/A	3.0
Limited borrowing capacity of municipalities	5.0	5.0	4.0	4.0	#N/A	2.0
Lack of private finance providers	1.0	1.0	1.0	4.0	#N/A	2.0
Too high interest rates to obtain a loan from public or commercial banks	3.0	1.0	1.0	4.0	1.0	2.0
High up-front investment cost	4.0	3.0	4.0	5.0	2.0	5.0
Low saved energy costs due to low energy prices	3.0	1.0	2.0	2.0	#N/A	3.0
Low saved energy costs due to the fixed energy bills which do not depend on energy consumption	3.0	1.0	3.0	2.0	2.0	1.0
Split incentives between street lighting infrastructure ownership and upgrade	3.0	1.0	2.0	5.0	#N/A	3.0
High risks of the project	1.0	1.0	2.0	2.0	1.0	2.0
High transaction costs	3.0	3.0	3.0	4.0	2.0	0.0
Low credit rating of municipalities	2.0	1.0	3.0	1.0	#N/A	3.0
The immature financial market	2.0	1.0	1.0	3.0	1.0	2.0

Notes: N/A means that there is no most frequent value.

Source: Survey results.

Based on the responses of municipalities and regional energy and development agencies, the barriers most frequently recognised as highly significant were insufficiency of 'own financial resources' and shortages in

financing from national and regional public budgets, as well as limited borrowing capacity of municipalities. This is the case in Croatia, Lithuania, and Italy, in particular.

The table provides one more example for the varying perception of barriers by the public sector and the private sector. In the opinion of manufacturers, the highest barriers also include the lack of private finance providers, overly high interest rates to obtain a loan from public or commercial banks, and split incentives between street lighting infrastructure ownership and upgrade; these barriers were given much lower significance by municipalities.

The responses also listed a number of other barriers. For instance, the respondents pointed to the immature ESCO market, the lack of financial instruments supporting energy efficiency, and overly complicated administrative procedures, which make the project expensive. One of the manufacturers also noted that energy savings are rather low because technologies like fluorescent and/or HID have already been installed, leading to very long payback times for exchanges with even higher efficiency technologies like LEDs.

In summary, stakeholder groups perceive rank and rate barriers differently. There are differences between public- and private-sector perceptions. This finding points to the importance of bringing together the public and private sectors for a discussion of relevant circumstances priorities and obstacles.

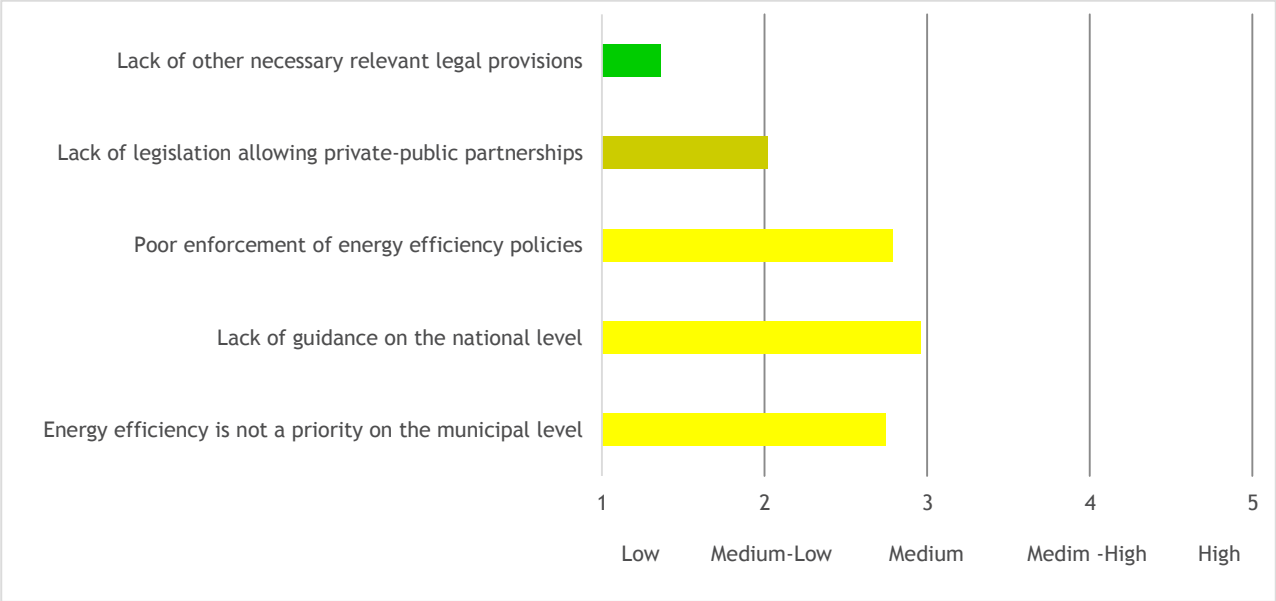
4.2. Barriers related to policy and framework

Next, the respondents were asked to rank their perception of the barriers related to policy and framework. The suggested list included such as barriers as:

- Energy efficiency is not a priority on the municipal level;
- Lack of guidance on energy efficiency actions on the national level;
- Poor enforcement of energy efficiency policies even though they exist, e.g., product standards for street lighting, green public procurement rules, and others;
- Lack of legislation allowing private-public partnership;
- Lack of other necessary relevant legal provisions;
- Other barriers.

Figure 4 presents the average perception of these barriers for the whole sample surveyed. The figure shows that, on average, the respondents believe that necessary legal provisions are in place; however, they identified as moderate barriers the poor enforcement of such provisions, lack of guidance on the national level, and low priority given to energy efficiency at the municipal level. Overall, the respondents perceive this barrier category to be less significant than the financial barriers category.

Figure 4: The average rating of barriers related to policy and framework of street lighting upgrades



Source: Survey results.

Table 11 presents the average rating within each stakeholder group for the barriers related to policy and framework. According to the survey responses, the research community and ESCs/ESCOs believe that the largest problem is poor enforcement of existing energy efficiency policies. Municipalities, as well as energy and development agencies, perceive the lack of guidance at the national level as the greatest obstacle.

Table 11: The average rating for barriers related to policy and framework of street lighting upgrades (by stakeholder group)

Respondents / Barriers	Municipalities	Energy or development agencies	Research / consultancy	Manufacturers	ESCs / ESCOs	Consumers
Energy efficiency is not a priority on the municipal level	2.0	2.0	2.8	1.4	2.0	3.0
Lack of guidance on energy efficiency actions on the national level	2.7	3.4	3.0	2.6	3.0	2.2
Poor enforcement of energy efficiency policies event though they exist	2.0	2.4	3.3	1.6	3.7	2.3
Lack of legislation allowing private-public partnerships	2.2	1.2	2.2	2.0	0.3	2.0
Lack of other necessary relevant legal provisions	1.5	0.6	1.1	2.2	1.0	1.0

Source: Survey results.

Table 12 presents the most frequent rating within each stakeholder group for barriers related to policy and framework. These values confirm what was previously anticipated, namely that respondents most frequently believe that energy efficiency policies should be better enforced. Moreover, energy efficiency should be better promoted at the municipal level, while national policy-makers should provide more guidance on energy efficiency actions. According to manufacturers, the lack of other necessary relevant legal provisions is also a significant barrier.

Table 12: The most frequent rating for barriers related to policy and framework of street lighting upgrades (by stakeholder group)

Respondents / Barriers	Municipalities	Energy or development agencies	Research / consultancy	Manufacturers	ESCs / ESCOs
Energy efficiency is not a priority on the municipal level	3.0	3.0	3.0	1.0	#N/A
Lack of guidance on energy efficiency actions on the national level	3.0	3.0	4.0	3.0	#N/A
Poor enforcement of energy efficiency policies even though they exist	3.0	4.0	4.0	0.0	3.0
Lack of legislation allowing private-public partnerships	1.0	1.0	3.0	3.0	0.0
Lack of other necessary relevant legal provisions	1.0	1.0	0.0	4.0	1.0

Notes: N/A means that there is no most frequent value.

Source: Survey results.

The respondents also identified other barriers. In particular, manufacturers see the lack of quality standards (e.g., preventing disturbance of residents by glare or light trespass) as a very significant barrier to investments in better lighting infrastructure. The representatives of energy and development agencies suggested that even in the most progressive countries regulations need to progress faster, as more could be done to stimulate investment. They also pointed out that local, regional, national and European financing schemes are not coherent and therefore must be better integrated. Finally, one respondent from the research community stressed that there are too few private actors active in sustainability and climate change mitigation to have a large cumulative impact. Therefore, additional measures must be taken to convince these actors to consider low carbon and sustainability issues as part of their decision-making process.

4.3. Barriers related to awareness, access to information and past experience

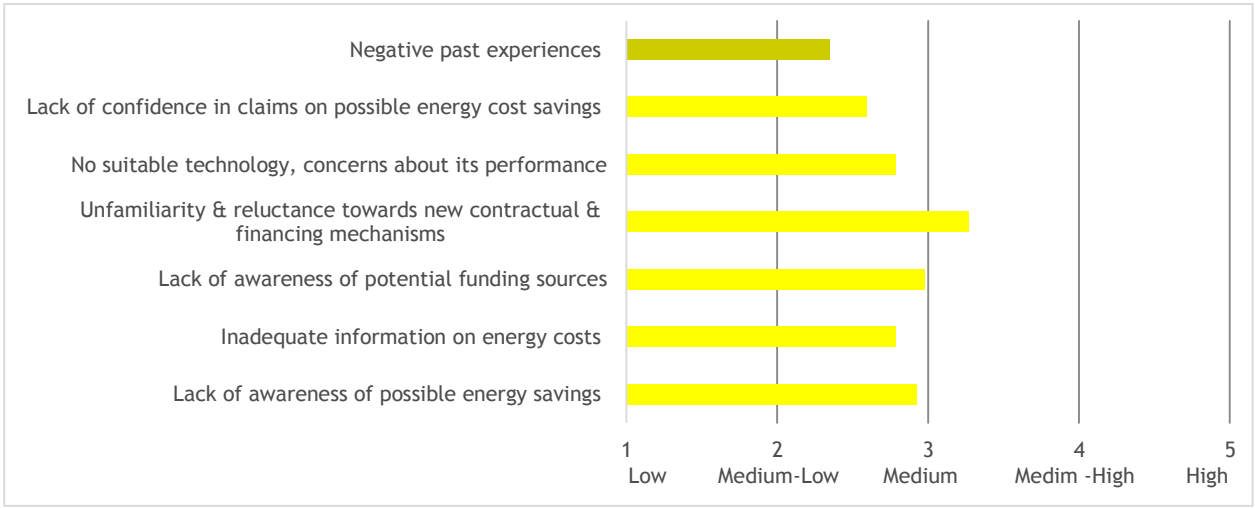
Barriers related to awareness, access to information and past experience were analysed as well. Survey respondents were asked to rate the significance of the following barriers:

- Lack of awareness of possible energy savings through the investment;
- Inadequate information on energy costs for street lighting;

- Lack of awareness of potential funding sources;
- Unfamiliarity with and/or reluctance towards new contractual and financing mechanisms (e.g., public-private partnerships, energy performance contracts, etc.);
- Difficulty in finding the most suitable technology solution in light of concerns about its performance and reliability;
- Lack of confidence in manufacturer or supplier claims on the possible energy cost savings attainable with a given solution;
- Negative past experiences with the implementation of similar projects;
- Other barriers.

Figure 5 presents the results for the whole sample surveyed. The survey results indicate that unfamiliarity with and/or reluctance towards new contractual and financing mechanisms was identified as the most significant barrier, even though its importance was still only regarded as moderate. Interestingly, the figure shows that, on average, negative past experience with the implementation of similar projects is rarely considered significant. Overall, the figure shows that this group of barriers has a rather minor effect on investment in energy-efficient street lighting.

Figure 5: The average rating for barriers related to awareness, access to information, and past experience of street lighting upgrades



Source: Survey results.

Figure 13 displays the average perception of these barriers by stakeholder group. The table illustrates that all stakeholder groups, with the exception of municipalities and consumers, believe that unfamiliarity with and/or reluctance towards new contractual and financing mechanisms is the biggest barrier. ESCs/ESCOs report experiencing difficulty in finding the most suitable technology solution that would perform well and be reliable. According to the manufacturers, investors often lack confidence in their claims on the potential savings in energy costs as a result of a specific solution offered. This respondent group is the only one that indicated having had negative past experiences with the implementation of

similar projects. Interestingly, municipalities perceive each barrier from the list as having low or medium-low significance.

Table 13: The average rating for barriers related to awareness, access to information, and past experience of street lighting upgrades (by stakeholder group)

Respondents / Barriers	Municipalities	Energy or development agencies	Research / consultancy	Manufacturers	ESCs / ESCOs	Consumers
Lack of awareness of possible energy savings through such investment	1.8	3.0	3.3	2.4	3.3	3.2
Inadequate information on energy costs of street lighting	2.0	2.8	3.2	2.0	3.3	2.2
Lack of awareness of potential funding sources	2.2	3.0	3.4	2.8	3.3	2.0
Unfamiliarity with and/or reluctance towards new contractual and financing mechanisms	2.3	4.0	3.5	3.2	4.3	2.2
Difficulty in finding the most suitable technology solution in light of concerns about its performance and reliability	2.5	2.8	2.8	2.8	4.0	2.0
Lack of confidence in manufacturer or supplier claims on possible energy cost savings of offered solutions	2.3	2.8	2.2	3.4	3.7	2.0
Negative past experiences with the implementation of similar projects	2.1	2.2	2.2	3.4	2.7	1.5

Source: Survey results.

According to Table 14, the barrier whose significance was most frequently rated medium-high among ESCs/ESCOs was unfamiliarity with new contractual and financing mechanisms. Manufacturers rated the significance of all barriers as high-medium or medium. Regional energy and development agencies believe that investing actors, including municipalities, are often not aware of potential funding sources. Again, interestingly, municipalities most frequently rate the significance of all barriers from this category as low, medium-low, or medium, but never high-medium or high. All other actors rate at least some barriers as medium-high.

Among other barriers, the respondents also pointed out that there is a lack of information on support from the EU funds and technical assistance programmes.

Table 14: The most frequent rating for barriers related to awareness, access to information and past experience of street lighting upgrades (by stakeholder group)

Respondents / Barriers	Municipalities	Energy or development agencies	Research / consultancy	Manufacturers	ESCs / ESCOs	Consumers
Lack of awareness of possible energy savings through such investment	1.0	#N/A	4.0	4.0	#N/A	4.0
Inadequate information on energy costs of street lighting	3.0	3.0	3.0	#N/A	#N/A	0.0
Lack of awareness of potential funding sources	1.0	4.0	4.0	3.0	#N/A	4.0
Unfamiliarity with and/or reluctance towards new contractual and financing mechanisms	3.0	3.0	4.0	3.0	4.0	0.0
Difficulty in finding the most suitable technology solution in light of concerns about its performance and reliability	1.0	2.0	3.0	4.0	#N/A	2.0
Lack of confidence in manufacturer or supplier claims on possible energy cost savings of offered solutions	2.0	3.0	3.0	4.0	3.0	3.0
Negative past experiences with the implementation of similar projects	1.0	2.0	1.0	4.0	2.0	3.0

Notes: N/A means that there is no most frequent value.

Source: Survey results.

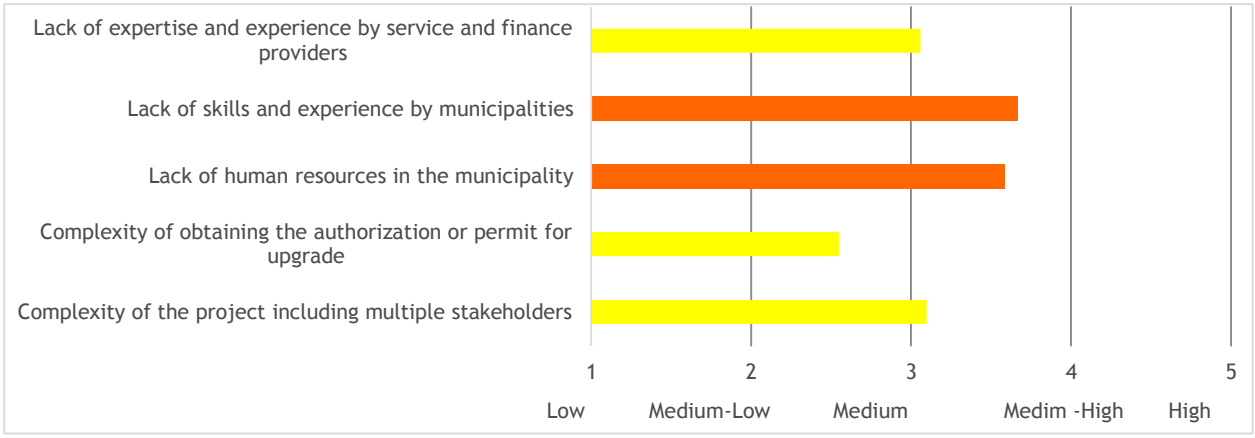
4.4. Barriers related to implementation capacity and procedures

As for the barriers related to implementation capacity and procedures, we asked whether any of the following barriers are significant:

- Complexity of the project, including the involvement of multiple stakeholders;
- Complexity of obtaining the authorisation or permit for street lighting upgrade;
- Lack of human resources in the municipality;
- Lack of skills and experience for the implementation of similar projects by municipalities;
- Lack of expertise and experience for the implementation of similar projects by service and finance providers;
- Restrictive public procurement rules;
- Any other barriers.

Figure 6 presents the average assessment of these barriers for the whole sample. As the figure shows, all barriers from this category were rated as medium on average. The highest barriers among these were the lack of human resources and necessary skills as well as the lack of experience for the implementation of similar projects by municipalities.

Figure 6: The average rating of barriers related to implementation capacity and procedures



Source: Survey results.

Table 15 provides the average rating for this group of barriers by stakeholder group. Interestingly, the table shows that researchers, ESCs/ESCOs, as well as energy and development agencies most often believe that the lack of skills and experience for the implementation of similar projects by municipalities presents high or high-medium barriers, whereas municipalities themselves perceive these barriers as not so high. Except for consumers, all respondents recognised the lack of human resources in the municipality as a high, medium-high or medium barrier. Energy and development agencies and researchers also believe that projects include multiple stakeholders and therefore are too complex.

Table 16 illustrates the most frequent rating for these barriers. As the table shows, overall, barriers in this category were ranked high. The table also shows that the lack of human resources by municipalities, as well as the lack of skills and experience for the implementation of similar projects by municipalities, are identified unequivocally as the greatest barrier by all stakeholder groups except for consumers. Furthermore, manufacturers frequently rated as a high-medium barrier the lack of expertise and experience for the implementation of similar projects by service and finance providers.

A few respondents also identified other barriers. The respondents observed that, even though the situation is different in each case, countries may have small municipalities that have very small budgets and, as a result, experience more significant financial difficulties than do large and rich municipalities. Furthermore, municipalities lack not only personal resources, but also inventories of the current status of street lighting infrastructure, 'master plans' and documentation with a strategy for tackling the task. One respondent argued that government-owned network distribution companies in charge of public lighting are an obstacle because they limit the access of private facilitators and ESCOs to projects. On the positive side, the respondents from some progressive countries reported that public procurement policies, including municipal procurements, recently started favouring energy efficiency solutions.

Table 15: The average rating of barriers related to implementation capacity and procedures of street lighting upgrades by stakeholder group

Respondents / Barriers	Municipalities	Energy or development agencies	Research / consultancy	Manufacturers	ESCs / ESCOs	Consumers
Complexity of the project including multiple stakeholders	2.3	3.6	3.2	2.8	2.3	2.7
Complexity of obtaining the authorization or permit for street lighting upgrade	2.3	1.8	2.7	2.0	2.3	2.2
Lack of human resources in the municipality	3.2	4.6	3.6	3.0	3.0	2.2
Lack of skills and experience for the implementation of similar projects by municipalities	2.5	4.6	3.8	3.2	4.3	3.0
Lack of expertise and experience for the implementation of similar projects by service and finance providers	2.4	2.4	3.1	3.2	3.0	2.8

Source: Survey results.

Table 16: The most frequent rating for barriers related to implementation capacity and procedures of street lighting upgrades (by stakeholder group)

Respondents / Barriers	Municipalities	Energy or development agencies	Research / consultancy	Manufacturers	ESCs / ESCOs	Consumers
Complexity of the project including multiple stakeholders	2.0	4.0	3.0	2.0	2.0	4.0
Complexity of obtaining the authorisation or permit for street lighting upgrade	3.0	2.0	3.0	1.0	3.0	0.0
Lack of human resources in the municipality	4.0	5.0	4.0	4.0	#N/A	3.0
Lack of skills and experience for the implementation of similar projects by municipalities	2.0	5.0	5.0	4.0	5.0	3.0
Lack of expertise and experience for the implementation of similar projects by service and finance providers	1.0	2.0	3.0	4.0	#N/A	4.0

Notes: N/A means that there is no most frequent value.

Source: Survey results.

5. Awareness and experience on financing

A subsequent series of questions investigated respondents' awareness and experience relevant to financing energy efficiency upgrades in street lighting infrastructure. The survey included questions about funding sources, financing instruments and financing models.

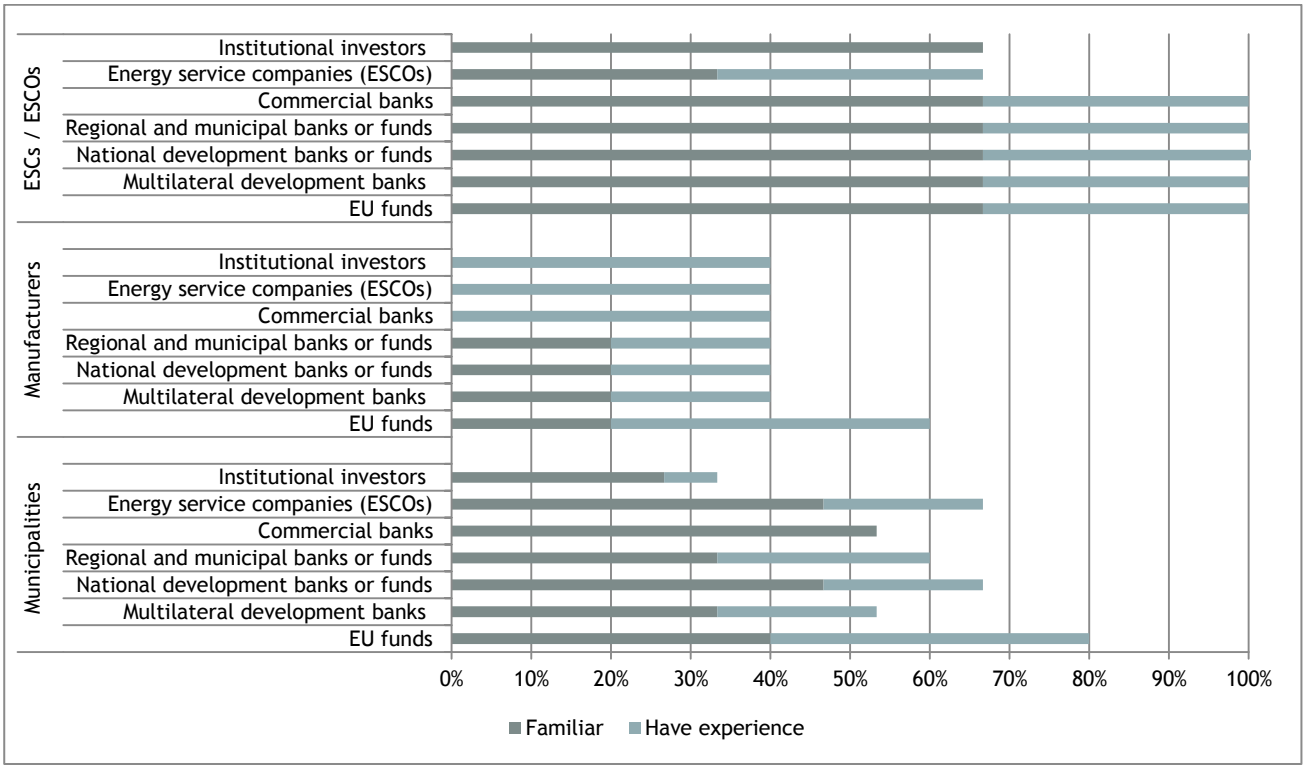
5.1. Funding sources

In this set of questions, the survey assessed whether different stakeholder groups were aware of existing funding sources and whether they had had experience applying for and using them. The survey listed the following funding sources:

- EU funds, e.g., European Regional Development Fund (ERDF) and/or Cohesion Fund;
- Multilateral development banks, e.g., European Investment Bank (EIB), European, Bank of Reconstruction and Development (EBRD);
- National development banks or funds;
- Regional and municipal banks or funds;
- Commercial banks;
- Energy service companies (ESCOs);
- Institutional investors, e.g., pension funds, insurance companies, investment funds, etc.;
- Other private sector actors.

Figure 7 presents the results of this analysis. The figure shows that 20%–45% of respondents representing municipalities do not have experience and are not aware of typical funding sources (the first five in the list). The most common source was EU funds: 40% of municipalities had used them and a further 40% were aware of them. The next common source for municipalities is national development banks and funds and financing through energy service companies. The good news is that roughly a quarter of municipalities are aware of rare sources, like institutional investors, and some of them even have experience working with them.

Figure 7: Knowledge and experience of municipalities, lighting product manufacturers, and contractors/energy services companies regarding different funding sources for energy efficiency upgrades of street lighting, % of the stakeholder group surveyed



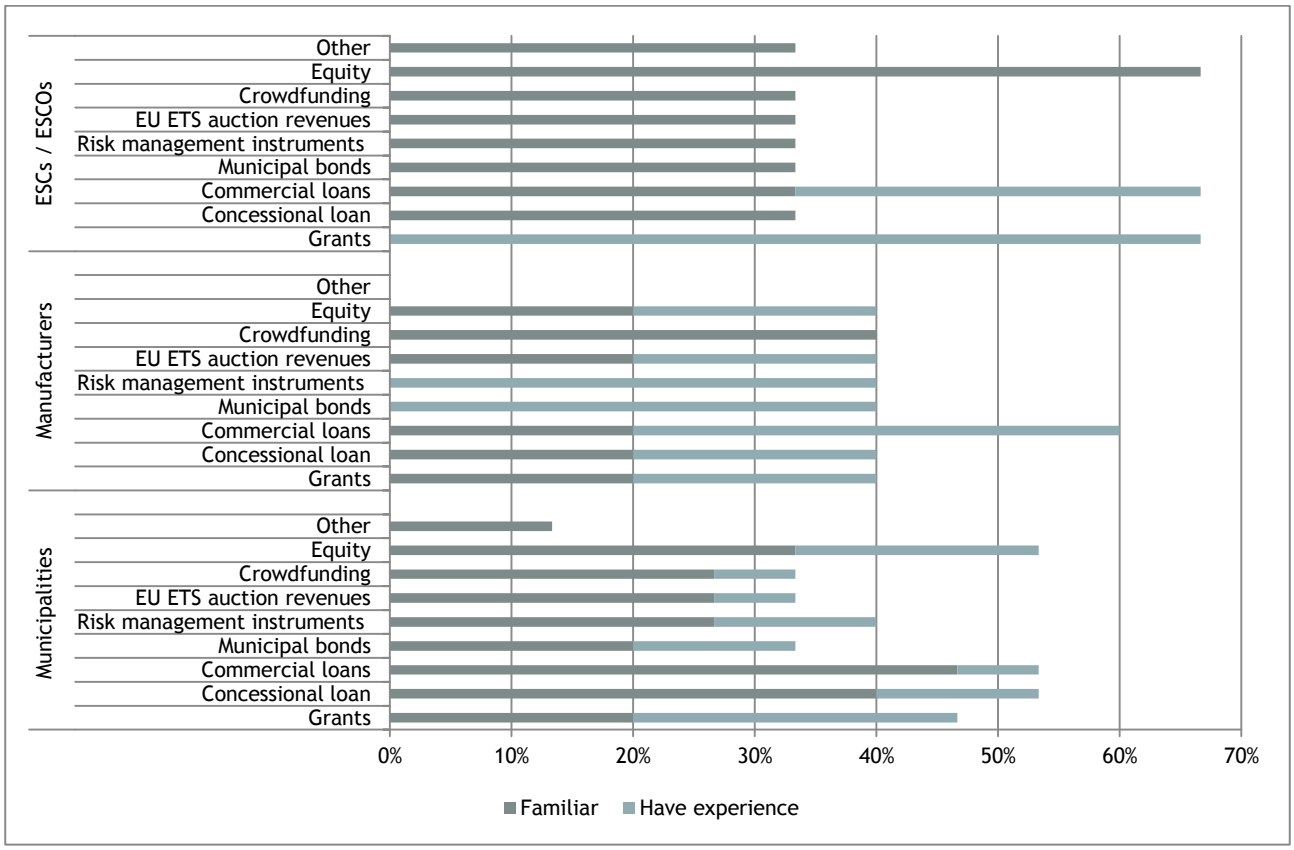
Source: Survey results.

5.2. Financing instruments

We also asked survey respondents which of the following financing instruments and schemes they have knowledge of or experience with for investment in energy-efficient street lighting. The list included grants; concessional loan, also called soft, low-interest, or preferential loans; commercial loans; municipal bonds; risk management instruments, e.g., loan guarantees, insurance policies, or other instruments to reduce investment risks; EU ETS auction revenues; crowdfunding; equity; and other instruments.

Figure 8 summarises the responses to this question. The figure shows that, most often, municipalities are aware of commercial and concessionary loans as well as equity investment. The familiarity with and experience using other instruments is less or equal to 40% in the base case. Roughly 40% of manufacturers are aware of or have used all listed instruments; most often, they have used commercial loans. ESCOs usually use equity for investing in street lighting; a third of ESCs/ESCOs surveyed have also had experience with all other instruments except for grants.

Figure 8: Knowledge and experience of municipalities, lighting product manufacturers, and contractors/energy services companies regarding financing instruments and schemes for energy efficiency upgrades of street lighting, % of the surveyed stakeholder group



Source: Survey results.

5.3. Financing models

Finally, we asked the survey respondents which of the following financing models they have knowledge of or have used. To help answer this question, we provided a choice of common models, as well as an option to name additional models not included in the provided list. The list of models included:

- Financing by municipality:
    - Using a revolving loan fund: A municipality sets up a revolving fund that will provide loans for energy-saving projects. As projects repay their loans to the fund, the returned resources are used for new investments;
    - Using internal performance contracting (Figure 9): A municipality sets up a dedicated fund or budget line, with initial financing from the municipal budget, which will finance energy saving projects by public bodies. Achieved cost savings are used to refinance the fund or budget line;
- Financing by municipality-owned or private utility:
    - Based on utility obligation schemes: A utility finances energy efficiency upgrades from a dedicated fund collected from on-bill charges or as part of the cost of doing business triggered by an energy efficiency obligation or white certificate scheme;

    - As part of doing business: A utility finances energy efficiency upgrades as part of doing business to manage its utility load shape;

- Financing by a private contractor (without energy performance contracting):
    - A standard contracting model between a private partner and a municipality (Figure 10): For a fixed fee, a municipality contracts a private partner, who plans, finances and implements a street lighting upgrade on the private partner's balance sheet;
    - A contracting model between a private partner, a municipality, and a bank, the so-called contracting model with forfeiting and waiver of defence (Figure 11): A municipality contracts a private partner to plan and implement the project on its balance sheet, with initial investment co-financed by the bank. The contracting fee paid by the municipality is split between the contractor and the bank;
- Financing by private partner through energy savings (i.e., with energy performance contracting [EPC]):
    - An EPC guaranteed savings model (Figure 12): A municipality contracts an energy service company (ESCO) to plan, finance and implement street lighting upgrade and guarantee a certain level of energy savings for a fixed annual fee based on the level of energy savings achieved;
    - An EPC shared savings model (Figure 13): A municipality contracts an energy service company (ESCO) to plan, finance and implement street lighting upgrade and guarantee a certain level of energy savings for a fixed annual fee based on the level of energy savings achieved. Any additional energy savings are shared between the municipality and the private partner.
- Financing by a private-public partnership:
    - A concession-based model between a private partner and a municipality (Figure 6): A municipality grants a concession to a private partner to operate and maintain street lighting infrastructure. The private partner can invest in energy saving measures and accrue all resulting benefits;
    - A leasing-based model between a private partner and a municipality (Figure 7): First, a municipality sells street lighting infrastructure to a private partner, and after the private partner upgrades it, the municipality leases it back and operates it;
    - Project finance (Figure 14): A municipality partners with private investors to plan, finance and implement a street lighting upgrade via a special purpose vehicle, which carries the investment on its balance sheet. The municipality pays monthly fees to the private investors.

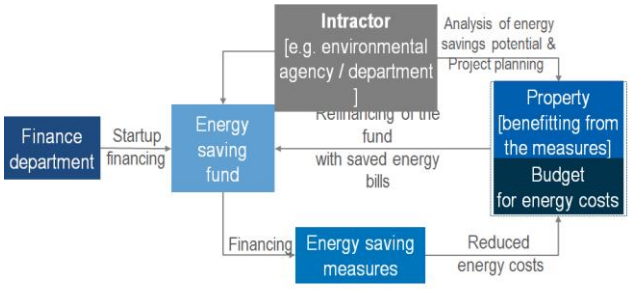


Figure 9: Internal performance contracting

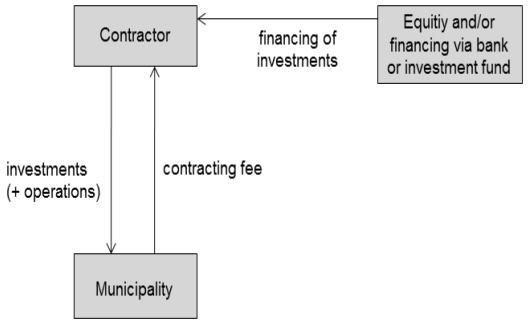


Figure 10: Energy performance contracting

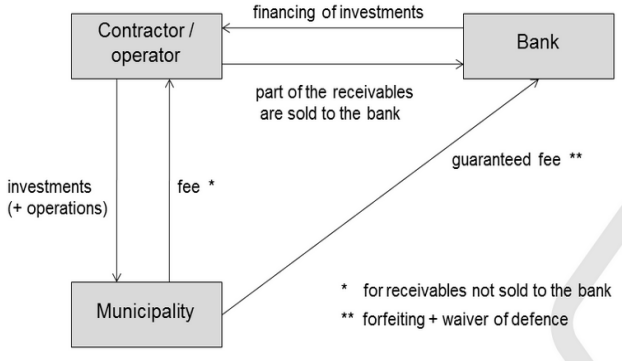


Figure 11: Contracting model with forfeiting and waiver of defence

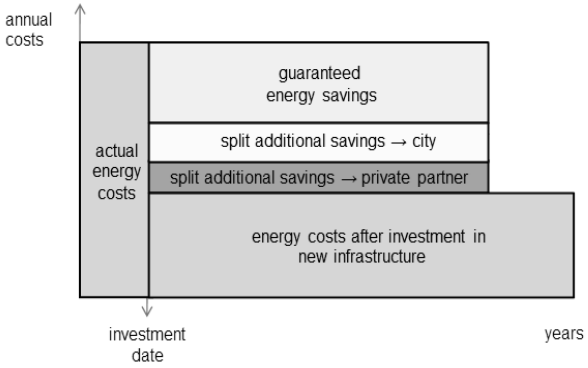


Figure 12: EPC guaranteed savings model

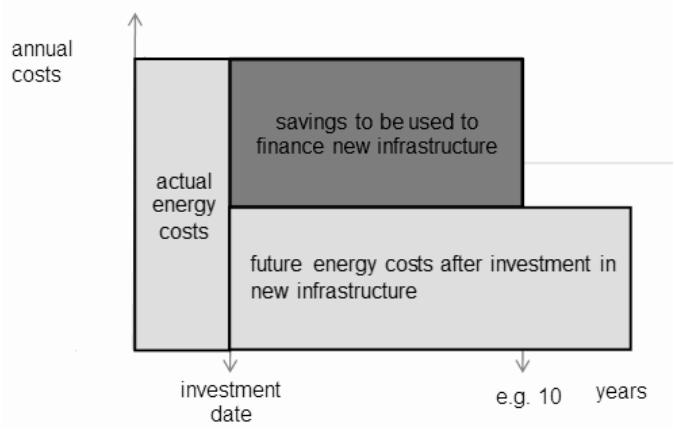


Figure 13: EPC shared savings model

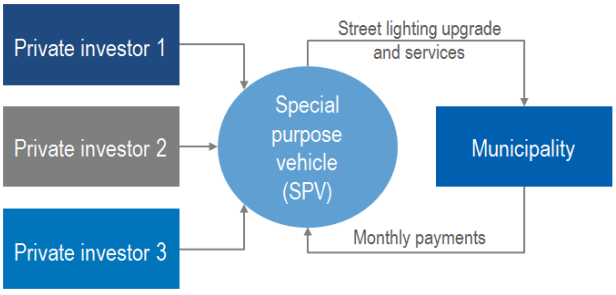
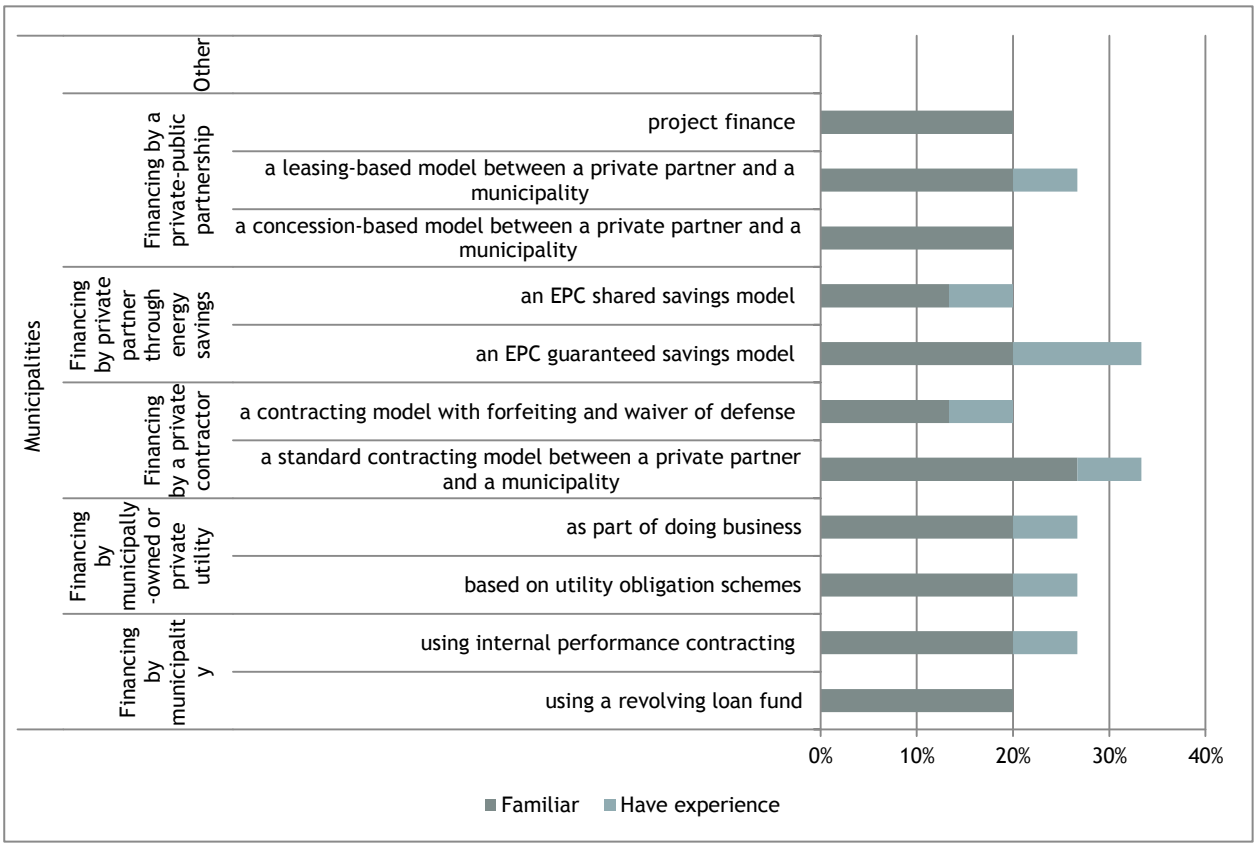


Figure 14: Project finance

Figure 15 illustrates the results based on answers from municipalities. One can conclude that municipalities have little experience with financing models; many of them have had no experience at all. The majority of municipalities have used a standard contracting model between a municipality and a private partner.

Figure 15: Knowledge and experience of municipalities regarding different financing models for energy efficiency upgrades of street lighting, % of the surveyed stakeholder group



Source: Survey results.

Figure 16 shows the responses of manufacturers on their knowledge/experience with financing models. Manufacturers reported a level of familiarity different than that reported by the municipalities. Most of all, they have used a standard contracting model between a municipality and a private partner, a consession-based model between a municipality and a private partner, as well as different types of EPC models.

Figure 17 summarises the results for ESCOs regarding their awareness of and experience with financing models. As expected, they are familiar with each model; however, internal performance contracting, the use of a revolving fund and—interestingly—financing based on utilities were the most common models.

Figure 16: Knowledge and experience of product manufacturers regarding financing models for energy efficiency upgrades of street lighting, % of the surveyed stakeholder group

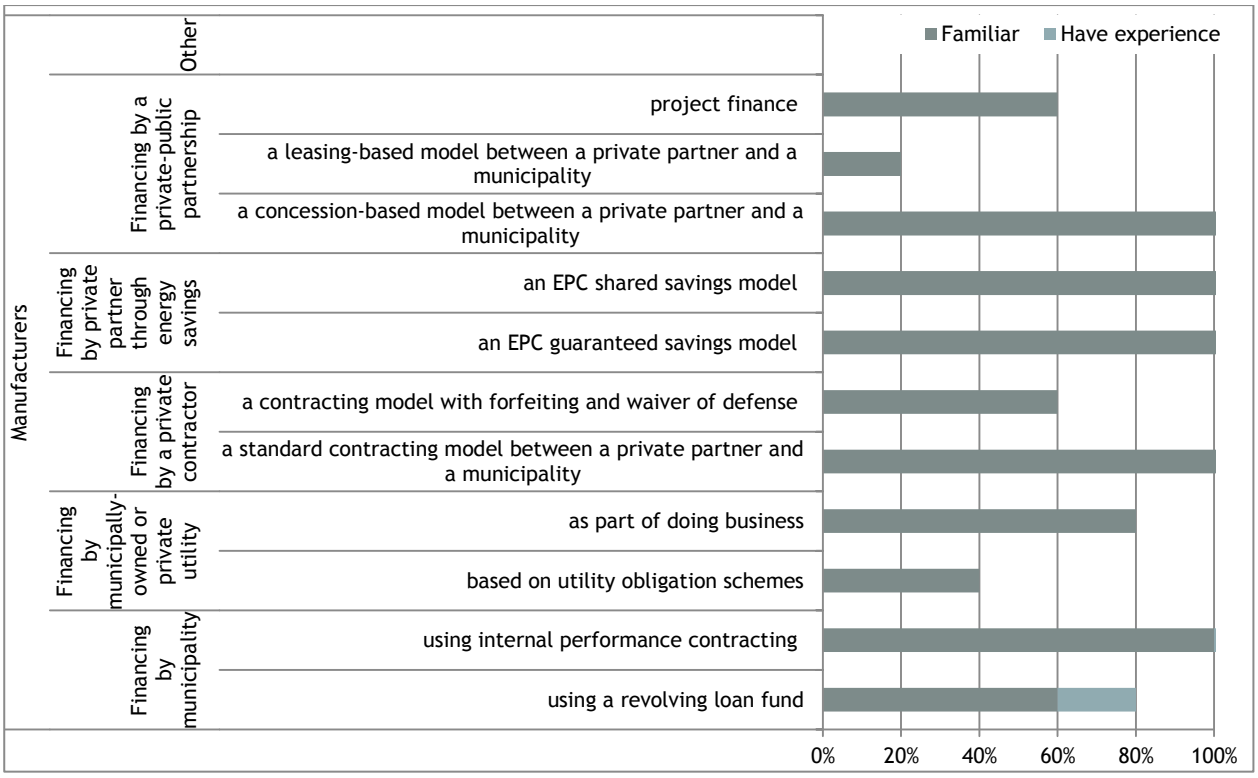
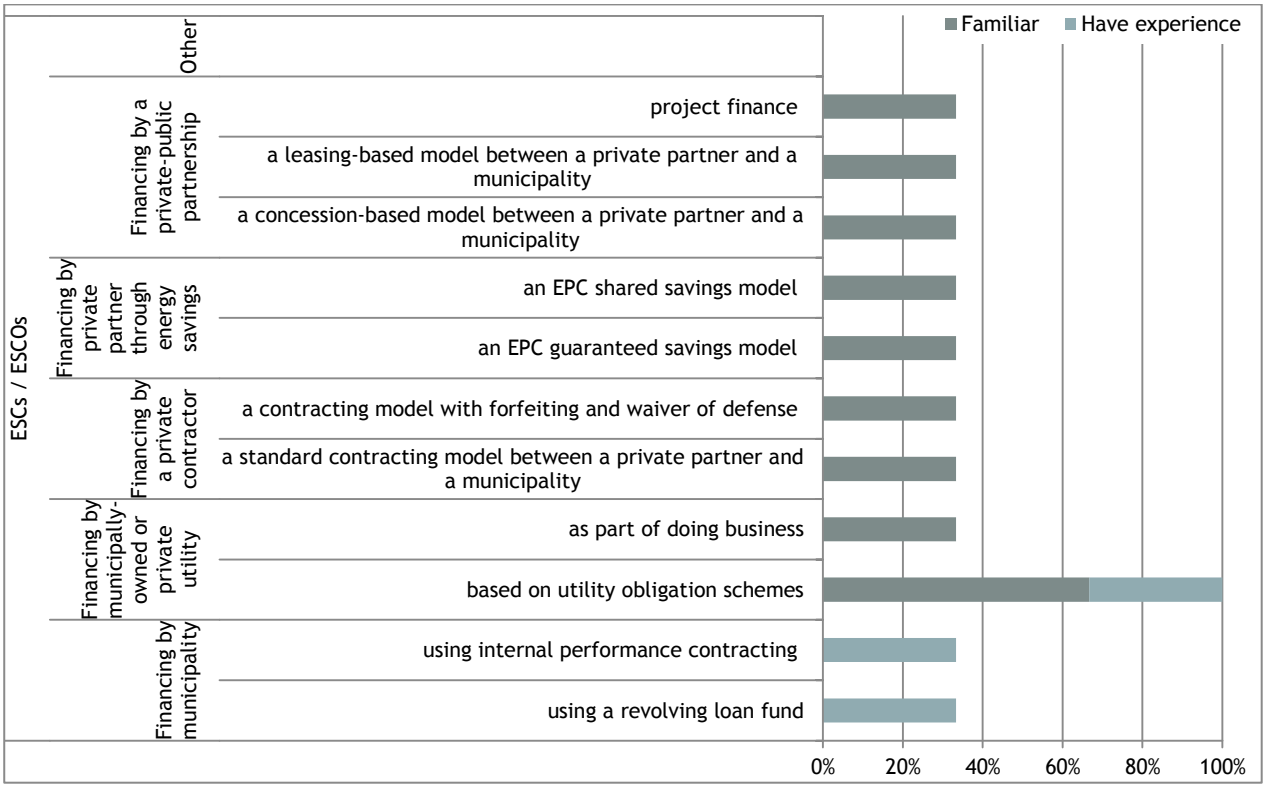


Figure 17: Knowledge and experience of contractors and ESCOs regarding financing models for energy efficiency of street lighting, % of the surveyed stakeholder group



Source: Survey results.

6. Conclusion and introduction to further project work

Based on the answers of survey respondents, we concluded that municipalities are legally responsible for the provision of street lighting in the majority of countries in Central Europe. Often, it is possible to transfer the legal responsibility under a concession agreement. In some countries, it is also possible to transfer the legal responsibility under the energy performance contracts and by creating public-private partnerships. In a few countries, the use of private capital is not allowed for the upgrade of public street lighting; this clearly represents an obstacle to leveraging additional finances for the upgrades.

We also concluded that the fragmented structure of the street lighting supply chain often poses a split-incentive barrier for its upgrade. In particular, the organisation responsible for providing proper street lighting may not necessarily own, operate and maintain street lighting infrastructure, and therefore those who must upgrade street lighting do not accrue benefits of this investment.

After a thorough analysis of the barriers to investment in the energy efficiency upgrade of street lighting, we found that financial barriers (such as high upfront investment costs, insufficient municipal budgets or a lack of national support) are the greatest perceived barriers. Policy- and awareness-related barriers were given lower importance that the financial barriers. Of the policy barriers, the greatest barriers were poor enforcement energy efficiency policies (even though they exist), and the greatest awareness barrier was unfamiliarity with and/or reluctance towards new contractual and financing mechanisms. The barriers related to implementation capacity were rated lower than the financial barriers but higher than policy and awareness barriers.

We found that the relative importance attributed to different barriers varies between respondent groups. For instance, researchers, ESCs/ESCOs, and energy and development agencies most often believe that the lack of skills and experience for the implementation of street lighting projects by municipalities are high or high-medium barriers, whereas municipalities themselves perceive these barriers as not so great.

We illustrated this difference between public- and private-sector perception of the barriers (i.e., what seems to be the most formidable barrier for the municipalities is not the primary investment concern for the ESCOs or manufacturers). Thus, municipalities see upfront costs as a high barrier and do not think that saved energy costs are low due to low energy prices. ESCs/ESCOs do not perceive upfront costs as high and see low saved energy costs due to low energy prices as a greater problem.

We observed a knowledge gap regarding existing national- and EU-level funding sources. Thus, many respondents from municipalities do not have experience in, and are not aware of, typical funding sources, even though they often do not have sufficient capital to finance certain projects. In our next deliverable, we will analyse the funding sources available to finance energy-efficient street lighting infrastructure (i.e., sources other than the resources of the municipalities). The report on funding sources should guide municipalities through a diverse funding landscape and help them find the programme or source most suitable for them.

We also saw a knowledge gap regarding possible financing models that could leverage more private finance. Our next deliverable provides an overview of existing financing models, such as innovative self-financing modes, debt-financing models, third-party financing, and public-private partnerships. The overview analyses these models using a common framework: it provides a summary of each model, identifies the projects to which it could be applied, specifies its advantages and disadvantages, and provides a case study.

Based on these two deliverables, we will prepare a set of recommendations for decision-makers on finding and implementing a suitable financing model; these recommendations will be submitted as the last deliverable. Finally, we plan to disseminate these deliverables and recommendations to municipalities and other actors (particularly those in the private sector) who may be involved in financing the energy efficiency upgrades of street lighting. The latter is an important step, because it will help to close the gap

between public and the private sectors and make each aware of the circumstances, priorities and obstacles relevant to other actors.

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Annex 1. Review of past projects

Several past projects can serve as examples and 'lessons-learnt-models' or best-practice projects. All of the projects aim to promote and/or improve the implementation of smart lighting systems in different areas.

The following review provides information on energy efficiency projects that address different aspects of the integration process for intelligent lighting and therefore promise to deliver positive results in many areas.

We found that few project reports have analysed the barriers to investment in energy-efficient street lighting.

Light-emitting diodes for both professional and consumer needs

The ENIAC JU project EnLight is a project consortium whose members include a large utility company; luminaire, ceiling-fitting and chip makers; and manufacturers of light-emitting diodes (LED) and LED modules. Six countries (Germany, France, Finland, Italy, Sweden and Holland) are involved in this project, the total cost of which is €41.3 million. The budget is provided by the ENIAC Joint Undertaking and contributions from national agencies in each of the consortium's participating countries. The project is motivated by the desire to achieve stronger integration of solid-state lighting (SSL) using LEDs, which would fulfil professional and consumer needs. This focus on user needs, with the requirements of all stakeholders taken into account, will produce smart solutions with the potential for mass-market acceptance. The future lies in intelligent LED control systems with energy-efficient dimming and fast switching capabilities. These systems facilitate improved integration, interoperability and cost control via energy-efficient LED drivers and modules. Unifying these components enables optimal use and integration of the LEDs, optics, heat management, electronics and control in modules. Stronger deployment of LEDs in professional and domestic environments will lead incrementally to product development and maximum efficiency (The ENIAC Joint Undertaking 2014). The project has shown the significance of lighting improvements by demonstrating energy savings potential of up to 80%, while maintaining or even enhancing user comfort (van Tuij 2015).

Urban public lighting

ENIGMA, a project funded by the European Commission, aims to revolutionise urban public lighting by implementing a joint transnational pre-commercial procurement (PCP) procedure. The overriding goal is to address challenges European cities are facing in a transnational context. For this purpose, the cities of Eindhoven, Malmö, Espoo, Stavanger and Bassano have formed a group to address a common public lighting challenge by integrating a PSP solution into daily life. This solution implies purchasing research and development services by the public sector, where market risks and benefits will be shared and development is competitive in all phases. PSP envisages the separation of the R&D phase from the procurement of existing products and services. PSP will therefore be seen as a tool to foster the innovation process (ENIGMA 2017).

ENIGMA is currently in its development and testing phase, having finished the research and screening process, online survey and interviews that helped identify certain types of cities for further research. Although lighting is a major topic, considerations regarding energy efficiency, safety and cultural heritage should be taken into consideration. After identifying needs and ambitions in collaborating municipalities, ENIGMA developed a so-called 'Call for solutions' to attract companies with innovative ideas, help them

with funding at the initial stage, and support them in developing new prototypes to be implemented eventually in partner cities (Ouden and Valkenburg 2014).

Smart lighting systems, especially adaptive lighting in an urban context, should be further developed and applied on a larger scale. Further development is only possible if there is sufficient knowledge of ICT within municipalities. Cooperation among different municipalities and their departments is also essential in order to implement smart solutions and explore new ones (Ouden and Valkenburg 2014).

Intelligent road and street lighting

The E-Street project is funded by the EU-IEE Save Programme and aims to address the issue of intelligent road and street lighting in Europe. The project involves 13 organisations from 12 European countries and includes 7 work packages, which define market potential and adequate financial schemes, adapting them to international standards and guidelines. The E-Street project describes adaptive and intelligent street lighting, defining the former as a system that can adapt performance to current needs, whereas the intelligent system is about advanced lighting, control and communication systems and administrative tools. Intelligent street lighting aims to lower energy consumption and maintenance costs while improving safety aspects. More than 20,000 adaptive luminaires were installed during the project period, January 2006–July 2008. According to the project outcomes, an annual savings potential of 38 TWh electricity was achieved. Such savings can be realised by refurbishing old installations with adaptive lighting. In addition, a new standard has been developed (under the International Commission on Illumination), and an administrative tool for handling adaptive lighting began operating in Oslo (European Commission 2008).

Despite the high energy-efficiency ratio of the new lighting systems, the public lighting sector is still one of the sectors in greatest need of investments. Public budget constraints have lowered investment. Several other barriers were also identified as hindering street lighting retrofit. Uncertainty regarding costs and benefits and a lack of financial models among stakeholders was one of the hindering factors. Furthermore, system management and maintenance challenged municipalities, as did the high upfront investment for technological requirements which will not be funded (McNally, Jonash, and Patel 2013).

Efficient implementation of local energy strategies in public lighting

Green Partnerships is a project to facilitate the contribution of local public authorities/communities towards the decarbonisation objectives of the EU. Work package 3 is of particular interest for this paper, since it describes a joint approach for more efficient implementation of local energy strategies, specifically in public lighting. The project examines measures to improve energy efficiency, namely via using LEDs, flow regulation systems (FRS) and remote management systems (Greenpartnerships n.d.).

In most cases, public lighting energy consumption represents 50 to 60% of the total energy consumption of a municipality. Increasing energy efficiency can mean savings of up to 40% in electricity bills. By applying LEDs and high pressure vapour sodium lamps it will be possible to double energy efficiency (over f.a. high pressure mercury vapour lamps) at a lower cost. FRS enables an adjustable management of lighting during at off-peak hours without forgoing major functions or reducing the security of the public lighting system. Additionally, it can reach lower levels of illumination, while at the same time reducing energy consumption, increasing the time between replacements of expendable materials and preventing a fast ageing of the luminaires as well as their components (Greenpartnerships n.d.).

Remote management systems are systems that control every luminaire within the system. They are able to react automatically to external influence (such as traffic density, weather conditions, etc.) and provide time- and cost-effective maintenance, especially in the areas of monitoring and diagnosis of failed lamps (Greenpartnerships n.d.).

Streetlight-EPC

In total, 63 projects with an overall investment of EUR 29 million were part of Streetlight-EPC. The project was implemented in nine regions, with twelve ESCOs as implementing partners and eight other companies that included EPC services in their portfolios. During the project lifetime, municipalities and interested SMEs were provided with support for setting up the EOC facilitation services. By doing so, the project enabled annual savings of 28 GWh and reduced costs by more than EUR 3.5 million. Based on project partners' continuous work on framework conditions for EPC, as well as experience gained in targeted countries, it was possible to formulate some important recommendations for the EU market (Streetlight-EPC 2017).

The project naturally experienced several challenges. One of the barriers was a lack of knowledge regarding technical and economic aspects. In addition, it was difficult to incorporate EPC into existing funding programmes. EPC market development in different regions and countries was quite heterogeneous, which led to additional challenges, such as diverse legal issues (e.g., regarding ownership, procurement), a lack of ESCOs, and specific needs and priorities of certain regions (OÖ Energiesparverband 2017).

GuarantEE project

As part of the guarantEE project initiative, 14 project partners are working on business and financing models using EPC for ESCO projects based on their performance. To date, a big pool of best practice projects has been implemented in Europe with the overriding goal of improving energy services and reaching maximum energy efficiency (Berliner Energieagentur GmbH 2017).

One of the best practice projects in terms of street lighting refurbishment took place in the city of Tona (Spain), which had suffered from insufficient public lighting investment and maintenance. Overall, the municipality benefited from the retrofit, achieving annual savings of almost EUR 60,000 and reducing CO2 emissions by 146.5t/a (Berliner Energieagentur GmbH n.d.).

Another example is the in-depth assessment of the Slovenian EPC-market with regard to buildings. Several barriers were identified which hinder further development. Most obstacles are primarily linked with economic motivation as well as limited financial capacity. As was the case in other projects, there was a lack of knowledge and skills regarding EPC procedures and the existing specific legal environment (Staničić 2017).

Based on the results of our review, we identified a need for an up-to-date, comprehensive catalogue of funding sources, financing models and case studies relevant to energy-efficient street lighting in Central Europe. Our forthcoming deliverables (under sub-task 2.3 of the Dynamic Light project) develop a catalogue of this kind.

Annex 2. Baseline inventory: questionnaire 1

Information about the consortium partner

1. **Which partner do you represent?** *

Mark only one oval.

- ◯ PP2. BSC, Poslovno podporni center d.o.o. Kranj, Slovenija
- ◯ PP3. PORSENNA o.p.s., The Czech Republic
- ◯ PP4. Međimurska energetska agencija d.o.o., Croatia
- ◯ PP5. Comune di Cesena, Italy
- ◯ PP6. TEA SpA, Italy
- ◯ PP9. Stadt Graz, Austria
- ◯ PP13. Poltegor-Instytut, Poland
- ◯ PP14. Hansestadt Rostock, Germany
- ◯ PP15. Grad Čakovec, Croatia

2. **Which territorial jurisdiction (country, region, city, municipality, or another) do you refer to in your answers?** *

_____

_____

_____

_____

_____

Characterization of street lighting infrastructure

3. **What is the number of street light luminaries in your jurisdiction?**

_____

_____

_____

_____

_____

4. **What is the share of the following lighting technologies in your jurisdiction?**
Mark only one oval per row.

	0% - 20%	21% - 40%	41% - 60%	61% - 78%	81% - 100%	Do not know
High pressure sodium (HPS)	◯	◯	◯	◯	◯	◯
High pressure mercury (HPM)	◯	◯	◯	◯	◯	◯
Complete light-emitting diode (LED) luminaries	◯	◯	◯	◯	◯	◯
Retrofit light-emitting diode (LED) lamps	◯	◯	◯	◯	◯	◯
Other technologies (compact fluorescent lamps – CFL, fluorescent tubes, and others)	◯	◯	◯	◯	◯	◯

5. **What is the age of street lighting infrastructure in your jurisdiction?**
Check all that apply.

- ☐ 0 – 10 years
- ☐ 11 – 20 years
- ☐ 21 – 30 years
- ☐ More than 30 years
- ☐ Do not know

6. **What is the total installed capacity of the street lighting infrastructure in your jurisdiction (in kW, if other units are used please specify)?**

_____

_____

_____

_____

_____

7. **How many hours per year the street lighting is used in your jurisdiction?**

_____

_____

_____

_____

_____

8. **What is the annual electricity consumption of the street lighting infrastructure in your jurisdiction (kWh, if other units are used please specify)?**

9. **What is the electricity cost of street lighting in your jurisdiction (euro cent or in another currency per kWh, if the currency is not euro, please specify it)?**

Technologies and practices used to reduce electricity consumption of street lighting

10. **Is a dimming schedule for the street lights used in your jurisdiction (Yes/No)? If yes, please specify the share of all street lights covered by the measure.**

11. **Is a schedule to switch off completely the street lights used in your jurisdiction (Yes/No)? If yes, please specify the share of all street lights covered by the measure.**

12. **Is a schedule to switch off one or several lamps of the street light luminaries used in your jurisdiction (Yes/No)? If yes, please specify the share of all street lights covered by the measure.**

13. **Is adaptive control, dependent on traffic intensity or the presence of people and/or cars, used in your jurisdiction (Yes/No)? If yes, please specify the share of all street lights covered by the measure.**

14. **Which other technologies and practices are used in your jurisdiction to reduce electricity consumption of street lighting? Please identify the measure and specify the share of all street lights covered by it.**

Actors related to street lighting

15. **Who is the owner of the street lighting infrastructure (in % of the ownership)?**
Mark only one oval per row.

	0% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%	Do not know
Federal government						
Municipal government or a company/ies, e.g. utility owned by municipality						
A private or partially private company/ies, e.g. utility/ies with the total or partial private ownership						
Other						

16. **Who operates the street lighting infrastructure (in % of the total infrastructure)?**
Mark only one oval per row.

	0% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%	Do not know
Federal government						
Municipal government or a company/ies, e.g. utility owned by municipality						
A private or partially private company/ies, e.g. utility/ies with the total or partial private ownership						

17. **Who makes the decisions about the modernization of the street lighting infrastructure?**
Mark only one oval per row.

	0% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%	Do not know
Federal government						
Municipal government or a company/ies, e.g. utility owned by municipality						
A private or partially private company/ies, e.g. utility/ies with the total or partial private ownership						

18. **If private or partially private companies own, operate, or make decisions about the modernization of the street lighting infrastructure, please provide more details about their nature.**

Financing the street lighting infrastructure

19. **Is public funding available for modernization projects using light-emitting diode (LED) lighting? If yes, is it possible to receive extra funding for dynamic* LED lighting?**
*Dynamic lighting refers to the lighting design of public spaces with the optimized light sources and light intensity that on the one hand reduces light pollution as well as energy consumption and on the other hand meets social needs.

_____

_____

_____

_____

_____

20. **Has already been or is currently the street lighting infrastructure retrofitted in your jurisdiction?**
If yes, we would be grateful if you send references, documentation, or further contacts in relation to these projects to aleksandra.novikova@ikem.de and matthias.hessling@swarco.com.
Mark only one oval.

- ◯ Yes *Skip to question 21.*
- ◯ No *Skip to question 29.*

Characterization of the past or current investment into the retrofit of the street lighting infrastructure

21. **Does/did the financing come in the form of:**

A subsidy or grant is public money that is not to be paid back. Public loan are also referred to low-interest, concessionary, soft, or subsidized loans.
Mark only one oval per row.

	0% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%	Do not know
A subsidy or grant	◯	◯	◯	◯	◯	◯
A public loan	◯	◯	◯	◯	◯	◯
Another loan	◯	◯	◯	◯	◯	◯
Own cash or the cash of another private actor(s)	◯	◯	◯	◯	◯	◯

22. **If the funding was fully or partially in the form of a subsidy or a public loan, which institution was the source**

ERDF - European Regional Development Fund
Mark only one oval per row.

	0% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%	Do not know
EU funds (ERDF, Cohesion fund, or another fund/s)	◯	◯	◯	◯	◯	◯
Federal government	◯	◯	◯	◯	◯	◯
Municipal government	◯	◯	◯	◯	◯	◯
Another source/s	◯	◯	◯	◯	◯	◯

23. **If the funding is/was provided through another loan, from which bank/s did it come?**
If it was an intermediary bank, please specify the initial funding bank and the intermediary bank if you have this information

_____

_____

_____

_____

_____

24. **If the funding is/was a loan, please specify its interest rate.**

_____

_____

_____

_____

_____

25. **If another private actor/s was/were involved into the financing model of the investment into the street lighting infrastructure, please specify it/them**
These could be lighting infrastructure operators, utilities, energy service companies (ESCOs), private companies (please provide more detail about their nature), other actors (please specify).

_____

_____

_____

_____

_____

26. **Who is/was the contractor modernizing the street lighting infrastructure?**
Mark only one oval.

- ◯ Lighting infrastructure operator/s
- ◯ Utility/ies
- ◯ Energy service companies (ESCOs)
- ◯ Other: _____

27. **How is/was the contractor modernizing the street lighting infrastructure paid?**
Mark only one oval.

- ◯ The payment is/has been included into the flat rate
- ◯ A separate payment is/has been made for the given modernization task/s
- ◯ Other: _____

28. **What was/is the level of involvement of the owner into the decision on the modernization of the street lighting infrastructure:**
Mark only one oval.

- ◯ No involvement is desired
- ◯ The owner would like to decide on the technology used
- ◯ The owner would like to decide on many or all technical aspects of the street lighting infrastructure
- ◯ The owner would like to be involved into the budget planning
- ◯ The owner would like to be involved into all decisions

Institutional arrangements regarding the investments into the retrofit of the street lighting infrastructure

29. **Is a green public procurement (GPP) law in place in your country?**

_____

_____

_____

_____

_____

30. **Is a law on Energy Performance Contracting (EPC) in place in your country?**
'Energy performance contracting' is a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure that relies on using cost savings from reduced energy consumption to repay the cost of installing energy conservation measures.

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_____

31. **If the street lighting infrastructure is owned by public actors, is private investment into the street lighting infrastructure possible?**

_____

_____

_____

_____

_____

32. **Is a special law on Public Private Partnership (PPP) required to enable private investment into the street lighting infrastructure? Is it in place?**

A public–private partnership (PPP) is a government service or private business venture that is funded and operated through a partnership of government and one or more private sector companies.

_____

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33. **If private investors are involved in the modernization of the street lighting infrastructure, do they usually guarantee a certain level of energy savings to the owners of this infrastructure? If yes, what happens when the energy savings achieved exceed or fall below the guaranteed level?**

_____

_____

_____

_____

_____

34. **Which financing architecture/s of the street lighting infrastructure modernization were/are used in your jurisdiction or country?**

Here come the pictures. If you are able, please send the details or name case studies to aleksandra.novikova@ikem.de and matthias.hessling@swarco.com.

Mark only one oval.

- ◯ A simple contracting model
- ◯ A model with the creation of a special purpose vehicle (SPV) company as an entity responsible for the project
- ◯ A joint venture model
- ◯ A private public partnership model
- ◯ Other models, please provide details
- ◯ Other: _____

Annex 3. Baseline inventory: questionnaire 2

1 1. General information

1.1 Are you answering this questionnaire on behalf of/as
(multiple answers are possible)

- A public authority: municipality
- A public authority: other
- An energy provider (utility)
- An equipment or material manufacturer
- An energy service company
- Another private service provider
- A finance provider
- A researcher

1.2 Please provide the name of your organisation, if you want to be acknowledged in project deliverables, which will be freely available on the project website and other websites.

1.3. Which territorial jurisdiction are you answering for:

Country:

Region:

Municipality:

Other, please specify

1.4 Please mark who has the legal responsibility (duty) to ensure proper steet lighting. Please also mark who owns, maintains, operates, and upgrades street lighting in your jurisdiction (if there are several actors, please mark multiple options)**:**

	Has the legal responsibility for proper street lighting	Owns street lighting	Maintains street lighting	Operates street lighting	Upgrades street lighting
Federal government	☐	☐	☐	☐	☐
Municipal government	☐	☐	☐	☐	☐
Companies owned by municipality, e. g. utilities	☐	☐	☐	☐	☐
Private or partially private companies, e. g. utilities with the total or partial private ownership	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

Under which circumstances may the legal responsibility (duty) to ensure proper lighting be transferred to another actor, for example a municipal government to a private company?

2 Barriers for investing in energy-efficient street lighting

What are the key barriers to investment in energy-efficient street lighting in your jurisdiction? [please mark as high, medium-high, medium, medium-low, or low for each barrier].

2.1 Barriers related to economic and financial aspects of street lighting upgrades

	High	High-Medium	Medium	Medium-Low	Low
Not enough own financial resources for owners of street lighting, e.g. municipalities or utilities	○	○	○	○	○
Not enough national or regional public funding	○	○	○	○	○
Restrictions on the use of public funding	○	○	○	○	○
Limited borrowing capacity of municipalities	○	○	○	○	○
Lack of private finance providers, e.g. commercial banks, energy service companies, contractors, institutional investors, etc.	○	○	○	○	○
Too high interest rates to obtain a loan from public or commercial banks	○	○	○	○	○
High up-front investment cost	○	○	○	○	○
Low saved energy costs due to low energy prices	○	○	○	○	○
Low saved energy costs due to the fixed energy bills which do not depend on energy consumption	○	○	○	○	○

Split incentives between street lighting infrastructure ownership and upgrade [e.g. when street lighting is owned by an actor who has low incentives to reduce electricity consumption whereas saved energy costs are accrued by another actor]	○	○	○	○	○
High risks of the project, e.g. energy price fluctuations, national currency exchange rate fluctuations, political instability, etc.	○	○	○	○	○
High transaction costs, e.g. the costs of the project preparation, tendering, and negotiation	○	○	○	○	○
Low credit rating of municipalities	○	○	○	○	○
The immature financial market, e.g. low availability of financial products and services	○	○	○	○	○
Other	○	○	○	○	○

2.2 Barriers related to policies and frameworks

	High	High-Medium	Medium	Medium-Low	Low
Energy efficiency is not a priority on the municipal level	○	○	○	○	○
Lack of guidance on energy efficiency actions on the national level	○	○	○	○	○
Poor inforcement of energy efficiency policies event though they exist, e.g. product standards for street lighting, green public procurement rulles, and others	○	○	○	○	○
Lack of legislation allowing private-public partnerships	○	○	○	○	○
Lack of other necessary relevant legal provisions (if yes, please specify):	○	○	○	○	○
Other	○	○	○	○	○

2.3 Barriers related to awareness, access to information, and past experience

	High	High-Medium	Medium	Low-Medium	Low
Lack of awareness of possible energy savings of such investment	○	○	○	○	○
Inadequate information on energy costs of street lighting	○	○	○	○	○
Lack of awareness of potential funding sources	○	○	○	○	○
Unfamiliarity and/or reluctance towards new contractual and financing mechanisms [e.g. public-private partnerships, energy performance contracts, etc.]	○	○	○	○	○
Difficulty to find the most suitable technology solution, concerns about its performance and reliability	○	○	○	○	○
Lack of confidence in manufacturer or supplier claims on possible energy cost savings of offered solutions	○	○	○	○	○
Negative past experiences with the implementation of similar projects	○	○	○	○	○
Other	○	○	○	○	○

2.4 Barriers related to implementation capacity and procedures

	High	High-Medium	Medium	Low-Medium	Low
Complexity of the project including multiple stakeholders	○	○	○	○	○
Complexity of obtaining the authorization or permit for street lighting upgrade	○	○	○	○	○
Lack of human resources in the municipality	○	○	○	○	○
Lack of skills and experience for the implementation of similar projects by municipalities	○	○	○	○	○
Lack of expertise and experience for the implementation of similar projects by service and finance providers	○	○	○	○	○
Restrictive public procurement rules	○	○	○	○	○
Other	○	○	○	○	○

If other, please specify

3 Opportunities for investment in energy-efficient street lighting

3.1 Has street lighting been renewed in your region within the last 10 years?

- ○ Yes
- ○ No

If yes, using which technology, e.g. LED?

3.2 If the street lighting infrastructure is owned by public actors, is private investment in the street lighting infrastructure possible?

3.3 What is the average duration to receive a permit for street lighting upgrades, in weeks?

[In the cases where private companies plan to build and operate the lighting infrastrucutre, they usually need to apply for a permit. This permit is granted or denied by the state authority]

3.4 What are the average costs for the permit of street lighting upgrades (euro or in another currency, if the currency is not euro, please specify it)?

[In the cases where private companies plan to build and operate the lighting infrastrucutre, they usually need to apply for a permit. This permit is granted or denied by the state authority]

3.5 Which successful examples in practice and policy to mobilising private investment in street lighting are you aware of? Which examples could be applied on a greater level?

We would be grateful, if you could send Internet links, the names of case studies, or documents to **aleksandra.novikova@ikem.de** and **matthias.hessling@swarco.com**.

3.6 Do you have knowledge of or experience with bundling several projects on street lighting upgrades in order to make them more attractive for private investors?

We would be grateful, if you could send Internet links, the names of case studies, or documents to **aleksandra.novikova@ikem.de** and **matthias.hessling@swarco.com**.

3.7 Do you have knowledge of or experience with the next funding sources and intermediaries for investment in energy-efficient street lighting?

	Familiar	Have experience
EU funds, e.g. European Regional Development Fund (ERDF) and/or Cohesion Fund	○	○
Multilateral development banks [e.g. European Investment Bank (EIB), European Bank of Reconstruction and Development (EBRD)	○	○
National development banks or funds	○	○
Regional and municipal banks or funds	○	○
Commercial banks	○	○
Energy service companies (ESCOs)	○	○
Institutional investors [e.g. pension funds, insurance companies, investment funds, etc.]	○	○
Other private sector actors	○	○

If with other private actors, please specify

If you marked, you have experience with the funding sources and intermediaries, please specify their names

3.8 Which financing instruments and schemes do you have knowledge of or experience with for investment in energy-efficient street lighting?

	Familiar	Have experience
Grants	○	○
Concessional loan (also called soft, low-interest, or preferential loans)	○	○
Commercial loans	○	○
Municipal bonds	○	○
Risk management instruments [e.g. loan guarantees, insurance policies, or other instruments to reduce investment risks]	○	○
EU ETS auction revenues	○	○
Crowdfunding	○	○
Equity	○	○
Other	○	○

If other, please specify

If you marked, you have experience with the funding sources and intermediaries, please specify their names detail e.g. volume, interest rates, or other conditions and characteristics

3.9 Which financing models do you have knowledge of or experience with for financing energy-efficient street lighting or other municipal infrastructure?

We would be grateful, if you could send Internet links, the names of case studies, or documents to **alek sandra.novikova@ikem.de** and **matthias.hessling@swarco.com**.

Financing by municipality
- using a revolving loan fund: A municipality sets up a revolving fund that will provide loans for energy saving projects. As projects repay their loans to the fund, the returned resources are used for new investments.
- using internal performance contracting (Figure 1): A municipality sets up a dedicated fund or budget line, with initial financing from the municipal budget, which will finance energy saving projects by public bodies. Achieved cost savings are used to refinance the fund or budget line.
Financing by municipally-owned or private utility
- based on utility obligation schemes: A utility finances energy efficiency upgrades from a dedicated fund collected from on-bill charges or as part of the cost of doing business triggered by an energy efficiency obligation or white certificate scheme.
- as part of doing business: A utility finances energy efficiency upgrades as part of doing business to manage its utility load shape.
Financing by a private contractor (without energy performance contracting)
- a standard contracting model between a private partner and a municipality (Figure 2): A municipality contracts for a fixed fee a private partner, who plans, finances and implements a street lighting upgrade on its balance sheet.
- a contracting model between a private partner, a municipality, and a bank, the so-called contracting model with forfeiting and waiver of defense (Figure 3): A municipality contracts a private partner to plan, and implement the project on its balance sheet, with initial investment co-financed by the bank. The contracting fee paid by the municipality is split split between the contactor and the bank.
Financing by private partner through energy savings (i.e. with energy performance contracting - EPC)
- an EPC guaranteed savings model (Figure 4): A municipality contracts an energy service company(ESCO) to plan, finance and implement street lighting upgrade and guarantee a certain level of energy savings, for a fixed annual fee based on the level of achieved energy savings.
- an EPC shared savings model (Figure 5): A municipality contracts an energy service company (ESCO) to plan, finance and implement street lighting upgrade and guarantee a certain level of energy savings, for a fixed annual fee based on the level of achieved energy savings. Any additional energy savings are shared between the municipality and the private partner.
Financing by a private-public partnership
- a concession-based model between a private partner and a municipality (Figure 6): A municipality grants a concession to a private partner to operate and maintain street lighting infrastructure. The private partner can invest into energy saving measures and accrue all resulting benefits.
- a leasing-based model between a private partner and a municipality (Figure 7): First, a municipality sells street lighting infrastructure to a private partner and after the private partner upgraded it, the municipality leases it back and operates it.
- project finance (Figure 8): A municipality partners with private investors to plan, finance and implement a street lighting upgrade via a special purpose vehicle, which carries the investment on its balance sheet. The municipality pays monthly fees to the private investors.
Other

Figure 1

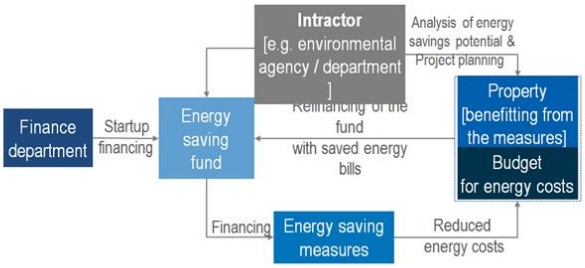

Figure 2

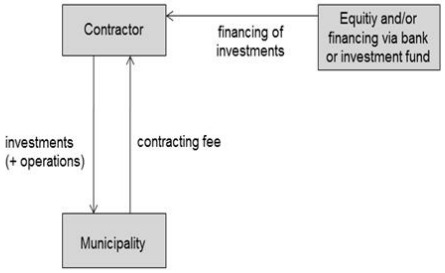

Figure 3

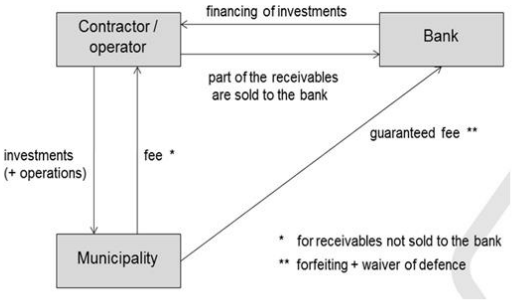

Figure 4