FINAL PUBLISHABLE REPORT

NEXT GENERATION OF ENERGY PERFORMANCE CONTRACTING – SMART EPC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101031639

Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101031639

Executive summary

The expanding role of public lighting as a platform for diverse urban services is explored. It details how Smart City concepts can be realized through the integration of energy-related services (like EV charging) and non-energy services into lighting infrastructure. The technical, legal and financial barriers to deploying these services are outlined, including power supply constraints, regulatory hurdles, and market immaturity. SWOT analyses is presented for key smart services, emphasizing the need for modular, adaptable approaches to service integration.

Preparation is a key to successful Smart EPC implementation. A suite of practical tools developed by the project is introduced, including factsheets, case studies, market assessments, technical specifications and a comprehensive handbook. These resources guide local authorities through project scoping, stakeholder engagement, feasibility analysis and the selection of appropriate technical and financial models. The importance is emphasized of data-driven planning, stakeholder involvement and the flexibility to adapt to local needs and regulatory requirements.

Smart EPC project implementation potential is addressed through a standardized, step-by-step methodology that covers project preparation, procurement and execution. The use of standardized documentation is detailed, such as energy audit methodologies, analytic tool, action plans, contract templates and tender documents, to streamline project development and ensure technical, legal and financial robustness. The Smart EPC contract and tender documentation are highlighted as central tools, enabling cities and municipalities to clearly define project scope, technical standards, performance guarantees and risk allocation. The documentation is designed for adaptability, allowing local authorities to tailor it to specific project requirements while maintaining standardization and market attractiveness. The importance of monitoring, verification and ongoing performance management throughout the contract lifecycle is underscored.

Pilot cities and municipalities including Karlovac, Krakow, Warsaw, Murcia, Rivas and several municipalities in the Auvergne Rhône-Alpes region adapted the Smart EPC model to their local contexts. Each pilot addressed specific challenges such as limited resources, heritage protection and technical integration, demonstrating the model's flexibility and replicability by prioritizing different combinations of energy efficiency and Smart City services. Key challenges included financial and administrative constraints, especially in municipalities, as well as complex national regulations and heritage protection requirements. Technical data gaps and the feasibility of integrating advanced smart services also posed difficulties, while local market readiness and supplier capacity influenced project outcomes. Effective stakeholder engagement and clear risk allocation were critical for success.

The role of the investor in Smart EPC pilots varied widely based on national regulations and local context. In France, legal restrictions meant that municipalities like Evian-les-Bains remained the primary investors, with contractors responsible only for performance, not financing. Other French municipalities also relied on municipal budgets and public tenders, often with technical support from regional agencies. In Poland, both Warsaw and Krakow shifted from planned EPC models to direct public investment, influenced by regulatory barriers and the availability of favorable public funding. Karlovac in Croatia was unique in implementing a full EPC model, where the ESCO financed the project and was repaid through energy savings. In Spain, Murcia is preparing a pilot with the city as investor, while Rivas managed upgrades internally without external financing. Overall, financing models ranged from classic ESCO-led EPCs to direct municipal funding, grant-supported procurement, and in-house implementation. The choice depended on legal frameworks, access to grants or loans, and the local market for ESCO services.

The guidance for cities and municipalities seeking to replicate the Smart EPC approach is provided. It emphasizes the value of standardized yet adaptable documentation and the importance of capacity-building resources for successful project preparation and implementation.

Finally, the project focuses on capacity building and knowledge transfer. The Smart EPC training materials is available, such as presentations, learning videos and webinars recordings, all developed to equip cities and municipalities, facilitators and ESCOs with the skills and understanding needed for successful Smart EPC implementation. Key lessons learnt from pilot projects are summarized, including the importance of early stakeholder engagement, political support and flexibility in contract design. The value of standardized documentation in reducing administrative burdens is highlighted, attracting market participation and supporting the integration of innovative non-energy services. The facilitation service aims to ensure that cities and municipalities can confidently prepare, procure and manage Smart EPC projects, maximizing both energy and operational benefits while laying the groundwork for broader Smart City development.

The cities and municipalities are provided with a complete, actionable framework for modernizing public lighting, integrating Smart City services and leveraging innovative financing and procurement models. Through practical methodologies, standardized documentation and targeted capacity building, the Smart EPC approach empowers local authorities to achieve sustainable, efficient and future-ready urban infrastructure.

1. Smart EPC project introduction

Next generation of energy performance contracting

The main objective of the Smart EPC project is to enable the transition towards smart, sustainable cities and municipalities by utilizing energy efficiency as a key potential of new, emerging technologies and services.

Refurbishment of old and inefficient public lighting units with the integration of IoT technology and Smart City components will pave the way for a wide range of energy and non-energy related services and applications, including public safety ensuring, traffic management, EV charging, environmental monitoring and next generation of cellular communication. **The main goal of the project is to develop standardized energy performance contracting (EPC) documentation for integrating energy and non-energy related services on public lighting system** (i.e. Smart EPC concept – Figure 1).

Key Smart EPC project activities:

a. **Integration of energy related services** (e.g. EV charging) **and non-energy related services in the public lighting system infrastructure** (e.g. communication services such as 5G and Smart City infrastructure);

b. **Development of standardized EPC** that includes a pay-for-performance scheme - real time data on performance of public lighting system infrastructure;

c. **Testing of the Smart EPC concept**: piloting reconstruction of existing public lighting systems by using standardized EPC that integrates other energy and non-energy related services).

Smart EPC project outputs are structured around three specific objectives:

- **First project objective** is development of standardized Smart EPC documentation for integration of energy and non-energy related services in energy performance contracting (EPC). The project will test reconstruction of public lighting systems by including other energy and non-energy related services (e.g. Smart City components like EV charging points, 5G relays for data transfer and communication, etc.) thus making EPC more attractive and financially viable to local authorities.
- **Second project objective** is demonstration of replication potential of Smart EPC documentation by piloting reconstruction of public lighting systems. Project goal is to demonstrate viability and effectiveness of project outputs (e.g. developed standardized processes and documentation). This demo actions will be done in three pilot countries across Europe (ES, FR and PL) with different market and regulatory circumstances.
- **Third project objective** is capacity building, replication and strong facilitation/dissemination service. Project will design and deliver a capacity-building program addressed to local authorities and consultants not being part of the project aiming to improve knowledge and skills in the EPC.

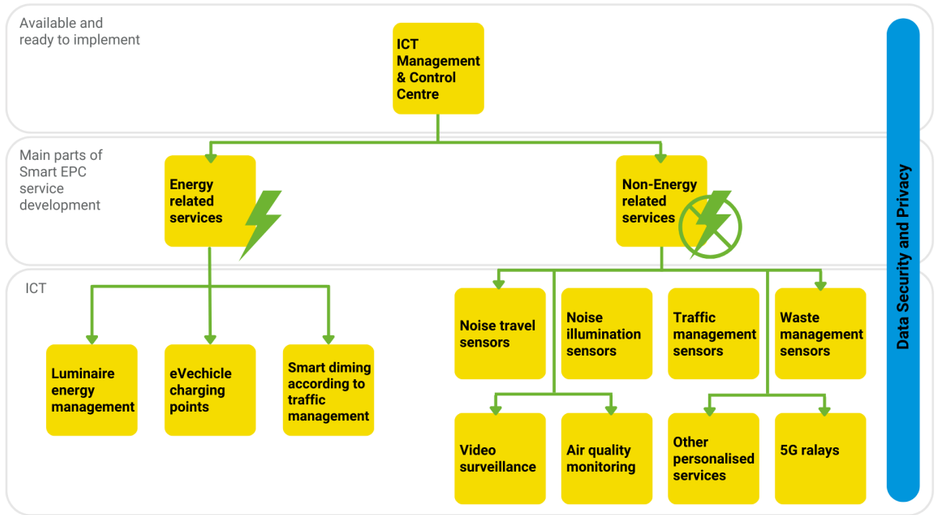


Figure 1 Smart EPC concept with integration of energy and non-energy related services

2. Energy and non-energy related services in public lighting

2.1 Smart City introduction

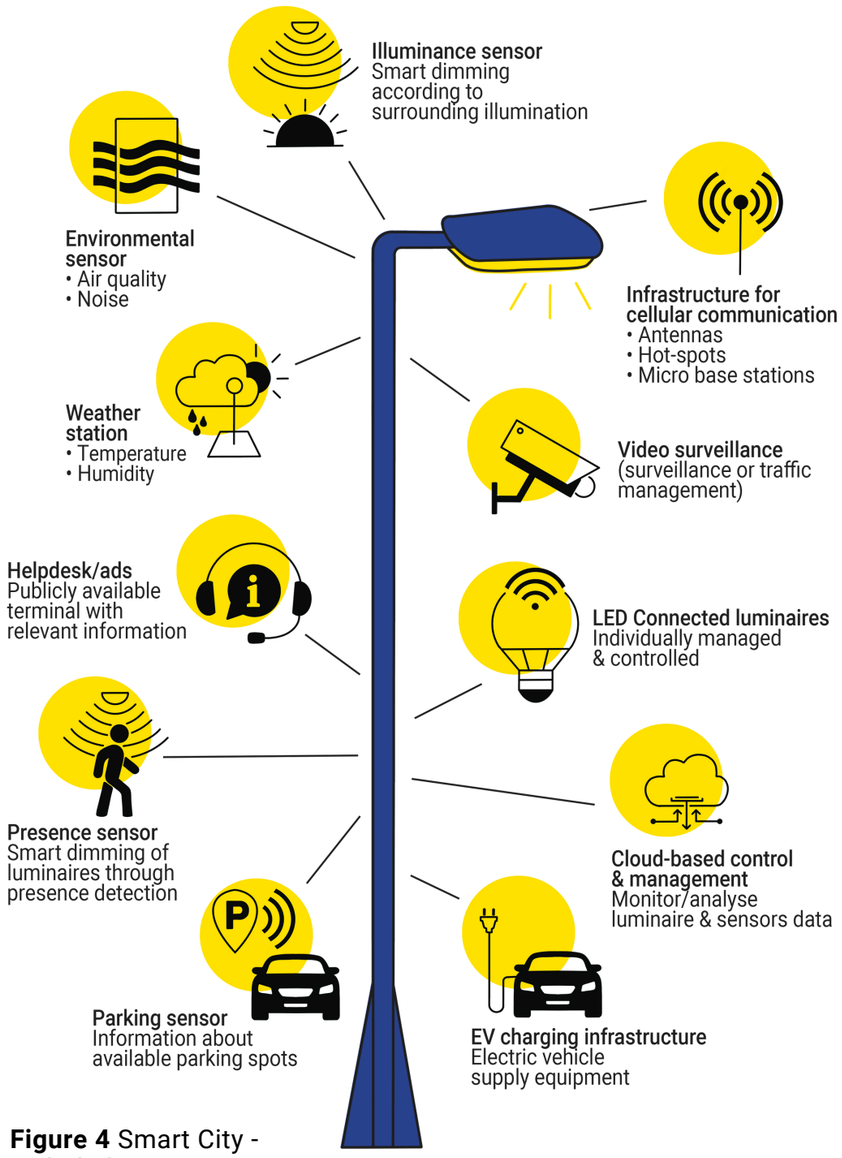


Figure 4 Smart City - included services

Smart City in general

Cities are growing at a staggering rate. As per the United Nations, currently, over half the total world's population lives in urban areas. This number is expected to jump to 68% by 2050. With the growing population, however, new challenges are also emerging for the city administration relating to public services. To overcome these challenges, cities are considering digital transformation. In other words, they are looking to become "Smart Cities". In a nutshell, a Smart City is a city that is able to collect and analyse all sorts of data from a variety of sectors, ranging from urban planning to waste management. **To become a Smart City, a city needs to build and maintain a streamlined network of interconnected sensors, systems and feature-rich software.** Today, most public lighting systems are still reliant on outdated technology based on traditional light sources. Replacing the existing public lighting systems infrastructure with innovative LED solutions and cutting-edge technologies results in saving energy and money, making public spaces safer and improving the life quality.

Smart City – public lighting system infrastructure

Modern public lighting system infrastructure offers an ideal point from which a diverse range of Smart City IoT applications and collecting an array of data can be fostered. Smart lamp posts don't just offer instant energy savings and maintenance cost reductions but also play an important role as one of the IoT infrastructures. It can be equipped with a weather station, wireless AP, camera, LED display, helpdesk or advertisement terminal, online speaker, EV charging point and other devices (Figure 4). **Smart lamp post becomes the data-collecting sensors of Smart City, ultimately achieving more efficient and integrated city.**

Public lighting system offers numerous infrastructure benefits, which make them a perfect base for hosting Smart sensors and systems:

- Power source – lamp posts have access to an uninterrupted power supply and can easily be adapted to secure power supply to other IoT devices, sensors and systems;
- Location – lamp posts are uniformly spread across local authority area. In addition, the height of each lamp post is consistent. Both the coverage and height of lamp posts make them ideal for hosting all sorts of IoT sensors and communication technologies, eliminating the need to set up ad hoc Smart City infrastructures;
- Safety – High above the ground, luminaires are normally out of the reach of pedestrians. In addition, due to the height, data collection (over-the-air) also becomes efficient.

Smart City – challenges

Moving to an integrated lamp post model, there are few major regulatory or policy barriers. However, across Europe, there can be a number of challenges that have to be overcome. Barriers can be summed up to:

- legal barriers: public concerns regarding misuse of collected data and abuse of people-related privacy right / data protection and cybersecurity issues / ownership of the lamp posts and operational contracts / legal liability of local authorities if traffic accidents occur when public lighting is dimmed or the equipment malfunctioning;
- policy barriers: conflict between incentives to reduce energy consumption and the promotion of the Internet of Things (IoT) solutions like Smart infrastructure which drives up consumption;
- financial barriers: city budget limitations prohibiting the investment in the transition to Smart connected lighting or integrated Smart lamp posts, high costs due to need for additional networks (internet, additional power supply);
- technical barriers: existing infrastructure outdated which requires new lamp posts installation to host Smart technologies / structural integrity of lamp posts to take the additional equipment / provision of 24-hour power supply / the availability of installed power for EV charging points on lamp posts / difficulties in installing new sensors (e.g. noise sensors) / more technical and safety training required for workers.

Smart City - key takeaways

- A Smart City is able to collect and analyze all sorts of data from a variety of sectors through a streamlined network of interconnected sensors, systems and feature-rich software.
- Modern public lighting system infrastructure plays an additional role as part of the IoT infrastructure when equipped with additional devices.
- Smart public lighting system results in energy and maintenance cost savings when operated and controlled to be adjusted in light levels based on the specific times and events, at the same time providing the near real-time status information of each luminaire.
- Besides light pollution decrease, Smart lamp post could have positive effect on air pollution, when equipped to monitor environmental factors (e.g. fine particulate matter concentration, temperature and humidity).
- Smart lamp posts could also have positive effect on city traffic when equipped with traffic management system providing traffic monitoring, traffic guidance, vehicle monitoring and parking guidance.
- Smart lamp posts could improve life quality by enabling EV charging, Wi-Fi hot spots, helpdesk or advertisement terminals and security cameras.

3. How to prepare Smart EPC project?

Under Smart EPC project, a number of documents and tools are being developed to help standardize EPC project preparation as well as to help inform local authorities on best practices and real life case studies.
To inform local authorities on Smart EPC concept and possibilities as well as on energy and non-energy services that can be included in EPC project a set of informative documents have been created to facilitate project preparation (Figure 7):

- Factsheets - to give local authorities a brief intro in to the Smart EPC concept;
- Case studies – to inform local authorities on real life case studies of implementation of different energy and non-energy services;
- ICT technology market assessment report – to inform local authorities in more detail on technologies used for provision of additional energy and non-energy services;
- Generic ICT Smart EPC concept and technology output specification – a set of technical and functional requirements of services to be delivered under Smart EPC project developed for local authorities to help them specify their needs and preferences.
- Handbook on Smart City and other ICT technology in EPC – to provide comprehensive overview of energy-efficient public lighting and financing models; centralised guide for the energy and non-energy related services in public lighting and the basic steps for preparation and implementation of the Smart EPC project.

Figure 7 A set of Smart EPC documents aimed at project preparation facilitation

3.1 Factsheets - key facts on public lighting, energy and non-energy services, and financing models

The structure of public lighting systems is outlined, emphasising the need for their upgrade due to outdated technology and inefficiency. The benefits of modernised systems include enhanced safety, reduced operational costs and readiness for Smart City applications.

EV charging points integration into public lighting system is highlighted as a commercial energy-related service. The challenges are addressed such as infrastructure limitations, legal and financial barriers. Despite these challenges, the integration of EV charging into public lighting system is presented as a space-saving and scalable solution.

The role of public lighting in Smart City initiatives is explored, emphasising its potential to host various IoT applications. Communication technologies, including licensed 5G and unlicensed options like LoRa, are discussed in the context of their integration into public lighting infrastructure as most recognised commercial non-energy related service. The challenges and potential revenue streams associated with these technologies are outlined.

The financing model of Energy Performance Contracting (EPC) is introduced as a key mechanism for implementing energy efficiency measures. EPC projects in public lighting are emphasised as simpler than those in buildings, offering a steppingstone for broader implementation in general.

FACTSHEETS

Key facts on public lighting, energy and non-energy services, and financing models.

Public lighting system infrasctructure

Figure 8 shows the disposition of the basic elements of public lighting system. The basic elements of the public lighting system are:

a. lighting distribution cabinets and supply cables
b. lamp posts
c. luminaires with a light source, optics and additional parts (e.g. Smart City components)

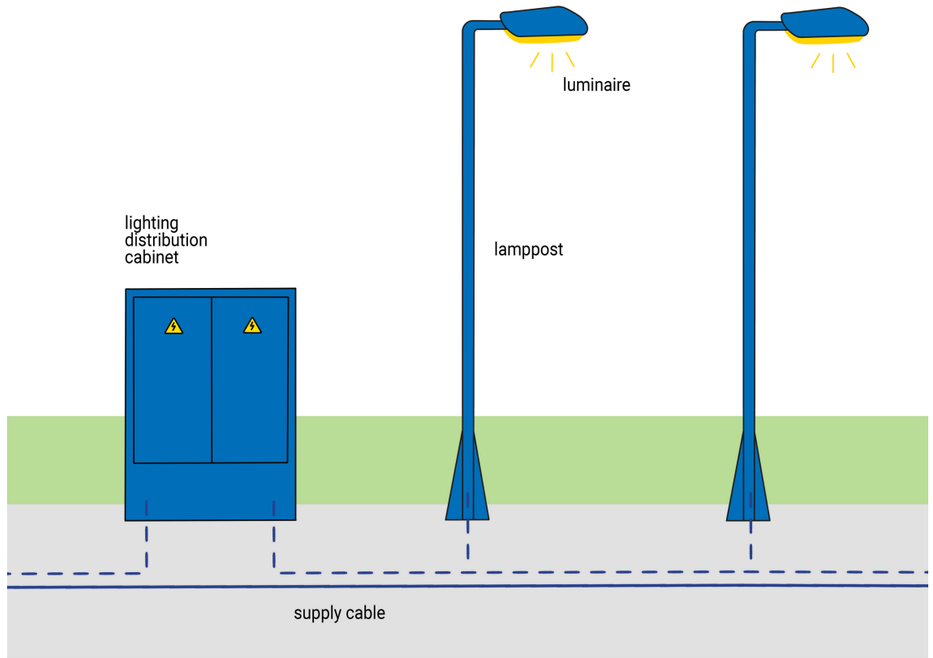


Figure 8 Disposition of the basic elements of public lighting system

3.2 Case studies - best practices in EPC, Smart City application, ICT Technology for energy and non-energy services in public lighting

Through the case studies presented in this paper, pilot projects across various cities demonstrate the successful implementation of different services that Smart EPC project focus on into public lighting system infrastructure. From Smart City applications to commercial energy services and non-energy services, these examples showcase the adaptability and efficacy of the integrated approach.

Public lighting systems, often underappreciated in their potential, embody the characteristics ideal for EPC interventions. Recognising the challenges faced by modern cities, including the imperative for energy balance, environmental sustainability, robust communication services, effective city management, citizen well-being and global city branding, the upgrade of public lighting systems with LED connected luminaires stands out as a key solution. The concept of Smart EPC extends beyond mere illumination. It envisions a comprehensive integration of additional services, such as environmental monitoring, EV charging solutions and communication technologies, into the existing smart public lighting infrastructure. This holistic approach transforms lamp posts into multifunctional hubs that cater to diverse urban needs.

CASE STUDIES

Smart public lighting - challenge and solution concept

The key solution to address some of the existing challenges would be the upgrade of public lighting systems with LED connected luminaires. However, some of the challenges need to be additionally addressed such as citizen well-being, city management and communication services. Hence, the concept behind Smart EPC is to get the most out of the smart public lighting system infrastructure to be able to monetize on additional services such as Smart City applications, e.g. environmental monitoring (that would allow local authorities to work more efficiently on citizen well-being and to have basis for sustainable urban development plans), EV charging solutions to increase sustainable mobility and last but not least, Communication technologies, e.g. street level 5G base stations (that allow for more connectivity with no need for building and construction permits extraction and additional infrastructure).

The ideal case would be the following:

- connected public lighting system infrastructure powered by the standard grid;
- environmental monitoring equipment mounted on the lamp posts to provide a grid of sensors that will give a clear picture (heat map) of air quality, noise level or temperature level (Smart City applications);
- EV charging solutions integrated within the lamp posts;
- Communication technologies e.g. street side 5G base station solutions for mobile connectivity, mounted on lamp posts.

Santander, Spain

UVAX monitoring and control platform for public lighting

Case study: Smart public lighting

Industry: Local authorities

Executive summary

The UVAX solution integrates in one platform all public lighting system management, control, regulation and all Smart City solutions using the electric power network (PLC). This technology has been implemented in the City of Santander, allowing the City to monitor and significantly reduce the energy consumption of 23 000 lighting points thanks to real-time regulation.

At-a-glance

Goal:
- Remote control and management of public lighting system from single place;
- Reduction of CO2 emissions in the city.

Approach:
- Creation of specific study on viability with detailed analysis of public lighting installations;
- Energy audit provision;
- Implementation of tender using ESCO model, for management and replacement of luminaires.

Results:
- Energy savings (from UVAX regulation only): 3 241 MWh/year;
- Energy savings (from both regulation and replacement of luminaries): 13 915 MWh/year;
- Economic savings (from UVAX regulation only): 205 mil EUR/year;
- Economic savings (from both regulation and replacement of luminaires): 1.029 mil EUR/year;
- The realization of an essential and tangible part of Santander Smart City strategy;
- Intensive stimulation of economic activity, generation of employment associated with the activity.

Featured solutions:
- 23 000 luminaires replaced and connected to UVAX;
- The installations renovation without technical and economic risk for the City Council;
- The outsourcing and optimization of the energy management within a framework of public-private collaboration.

The challenge:

Santander is a coastal city located in the north of Spain, capital of the autonomous community of Cantabria, with 171 693 inhabitants (2022).

The Santander City Council is oriented towards guaranteeing the security of the energy supply, its economic efficiency and respect for the environment, and has developed a series of actions whose central axis is the Integral Energy Efficiency Plan.

With the aim of reducing energy consumption during low occupancy hours, public lighting monitoring and control systems needed to be implemented. With this aim, the City needed to tackle the existing situation:

- Antiquated lighting system with no monitoring or regulation and with high energy consumption;
- No inventory or energy audit of the 23 000 lighting points throughout the city;
- Low energy efficiency awareness from the citizens;
- Light pollution.

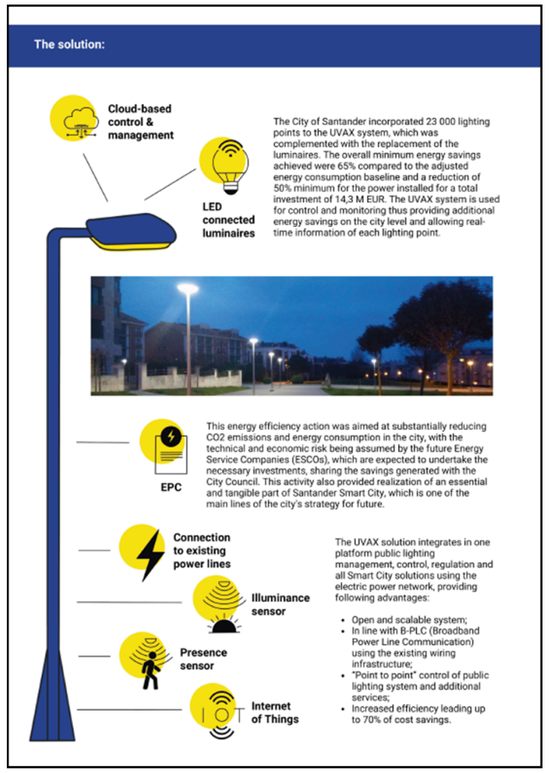


Figure 9 Smart EPC case study - challenge and solution concept

3.3 ICT technology market assessment report - strategic insights into the market's potential and the implementation challenges

The Smart EPC project addresses challenges in existing EPC schemes, such as accuracy issues and the absence of protocols for incorporating new technologies. It identifies opportunities in the convergence of energy efficiency and emerging technologies while recognising the importance of standardised procedures for measurement and verification.

The project emphasises the integration of 5G networks, IoT and Smart City components (Figure 10). It recognises the pivotal role of public lighting in smart cities, envisioning multi-functional street infrastructure supporting services like 5G base stations, environmental monitoring and EV charging. The technology trends highlight the exponential growth of mobile data traffic and the necessity for network densification. The implementation of 5G and EV charging solutions involves addressing challenges in site acquisition, power infrastructure and the need for seamless integration with existing systems.

ICT TECHNOLOGY MARKET ASSESSMENT REPORT

Recommendations – The Smart EPC upgrade action package

State of the public lightning, potential of reconstruction, legal and financial risks and problems seem to be quite similar across the EU countries. This gives an opportunity to develop a uniform EU market for reconstruction of public lightning via EPC type of contracting. Numerous new technologies that can be incorporated in public lighting systems such as smart sensors, smart metering, etc. create an environment where smart solutions and application can thrive and boost cities and counties in a new digital/smart era where these technologies enhance safety and quality of people's lives (Smart City aspects). **Public lighting systems make an ideal infrastructure for this to happen.** In order to do so, on EU level, standardised EPC documentation that promotes and requires this kind of ICT solutions needs to be developed and accepted. This would open the EU market and break down national boundaries for ESCO companies since all documentation would be practically the same.

If there was a standardised contract and tender documentation for this kind of projects, all ESCO companies interested in specific tender could analyse specific tenders and prepare their bids in much shorter time. This would lower preparatory costs not just for public sector and ESCO companies but also for financial institutions financing this kind of projects making them more financeable. Making EPC methodology and documentation creates an "off the shell" solutions for public sector and "off the shell" products for ESCOs and financiers which should lead to more vivid market.

Standardisation of contracts and methodology creates a pool of projects that have quite similar risk profiles (same legal clauses, same technical requirements etc.) which helps create a sound market conditions for lowering the cost of capital as well as opening room for development of secondary markets. Also, technical requirements for ICT solutions brings IT and telecom industries in story making them essential part of developing new solutions and services baking up or leaning on energy efficiency as a core problem. This helps in bringing together different market/industry players much faster than they are doing now and helps EU in transformation to smart digital society based on energy efficient measures.

Market drivers

As much as the life of modern person gets increasingly complex and multidimensional, the overall management of City life gets more and more complex each year as well in all of it aspects. The city management requires complex and smart integrated IT backbone, open and interactive to citizens as well as to all the city management service organisations. The city also needs to be interconnected with the whole country and global people, information, goods, and energy networks. This Management system needs to be live and interactive flexible system growing, adapting, and developing with the city.

Citizen wellbeing means that the city life is adjusted to citizen life in terms of all their daily needs, sensing life of the citizens, adapting to it, and interacting with it. Modern city needs to adapt to daily rhythms and movement patterns of its citizens.

By providing a high level of citizen wellbeing and a healthy integration within its own county and international community, the city advances in its global positioning and branding. This is also highly interconnected with the spirit of uniqueness and creativity expressed by the city and its citizens. The better the city's global perception and positioning the quicker prosperity of the city.

SWOT Analysis - EV charging

Strengths	Weaknesses
1. Quick installation (in some examples up to 1 h); 2. Integration with the existing infrastructure - Space-saving, no extra street furniture; 3. Easy charge; 4. Energy grid-friendly; 5. Can be planned at short notice; 6. Easy to relocate if required; 7. Have low investment and operating costs; 8. Network-compatible; 9. Easy access to charge points, especially for people without private parking spaces; 10. Variety of payment options; 11. Can be usable with type 2 standard cable; 12. Charging while the EV is parked anyway; 13. Fully standard-compliant.	1. If cable would need to be stretched across the footpath onto the road this would cause a potential trip hazard; 2. Challenge with the amount of power available; 3. Slow charging; 4. High costs for the option of installing smart lighting; 5. There's no way to tell if a charger is available at any given time (without dedicated parking).
Opportunities	**Threats**
1. Strong increase in EVs in Europe (40 million EVs in 2030); 2. Expansion of bans for combustion engine cars in major cities; 3. Strong expansion of urban charging infrastructure necessary; 4. Cities will need significantly more public, quickly scalable and easily accessible charging stations soon; 5. Electricity is already available all around us; 6. Funds and policies of the European Union.	1. Many lamp posts may not even be suitable for charging equipment; 2. A long distance from the public lighting pole to the parking lot; 3. Measuring of the charge points; 4. Laws and regulations; 5. Required permits; 6. Vandalism.

SWOT Analysis - 5G technology

Strengths	Weaknesses
1. Facilitates bulk-site approvals for cities, 2. Enables site permits in difficult areas, 3. Overcomes site acquisition issues, deploys in one day and reduces OPEX 4. Supports all technologies as well as micro, macro, Wi-Fi/camera/environmental sensors, fiber, antenna, and MINI-LINK are possibilities. 5. Houses equipment both inside and under the lamppost. Tailored to city infrastructure to ease acquisition, invisible connectivity appreciated by citizens 6. Generates energy savings of 50%-70% through efficient LED lighting 7. Provides better quality of light – besides an LTE/5G or other connection 8. Strengthens mobile broadband coverage in cities and seamless communication in dense areas inside city	1. Regulatory requirements regarding spectrum lease 2. Potentially increased CAPEX 3. Usability 4. Resilience
Opportunities	**Threats**
1. Regulatory requirements regarding spectrum lease 2. Potentially increased CAPEX 3. Usability 4. Resilience	1. Qualified workforce available on the market 2. Public perception on health concerns 3. Capital investments 4. Technology advancement

Figure 10 SWOT analysis results of Smart EPC components

SWOT Analysis - Smart Lighting

Strengths	Weaknesses
• existing availability of mechanical and electrical infrastructure in the system • high density and very good positioning of the infrastructure of existing public lighting • high achieved level of electrical, communication and software standardisation • significant reserves in available electrical power due to the high increase in energy efficiency of luminaires achieved by LEDification • increasing availability and decreased cost of smart public lighting systems • high technological similarity and compatibility with solar power systems • minimum production of hazardous waste during the life cycle of public lighting	• susceptibility to disturbances of electronic components (drivers and LEDboards) and mechanical (aluminium) raw materials markets • insufficient standardisation on the interfaces between the basic components inside the LED luminaires (driver and LEDboards) • insufficient adaptation to the relatively low level of cleanliness of electricity networks for the power supply of public lighting systems (especially air suspended networks). • short life cycles of communication solutions in relation to the expected life cycle of public lighting systems (minimum 15 years)
Opportunities	**Threats**
• energy saving trend related to the global energy crisis • trend of automation of public system maintenance jobs • environmental trend related to the global environmental crisis (protection against light pollution, hazardous waste generation) • trend of switching to "Light as a service" business models • trend of integration of the smart city systems and citizens via smartphones • trend of switching to autonomous power sources (solar systems) • trend of digitalization advertising • trend of increasing need for video security systems	• lack of expertise in the public and legislative system and instability of legislation • lack of experience in the public lighting sector with communication systems • insufficient levels of expertise on new technologies among traditional investors and public lighting installers • public sector budget constraints due to the global financial crisis • slow process of creating the market needs of citizens to use smart city data via mobile apps • weak resilience of legislation to the transfer of political conflicts to the field of contracting of infrastructure systems • increased complexity in planning the maintenance of public lighting systems

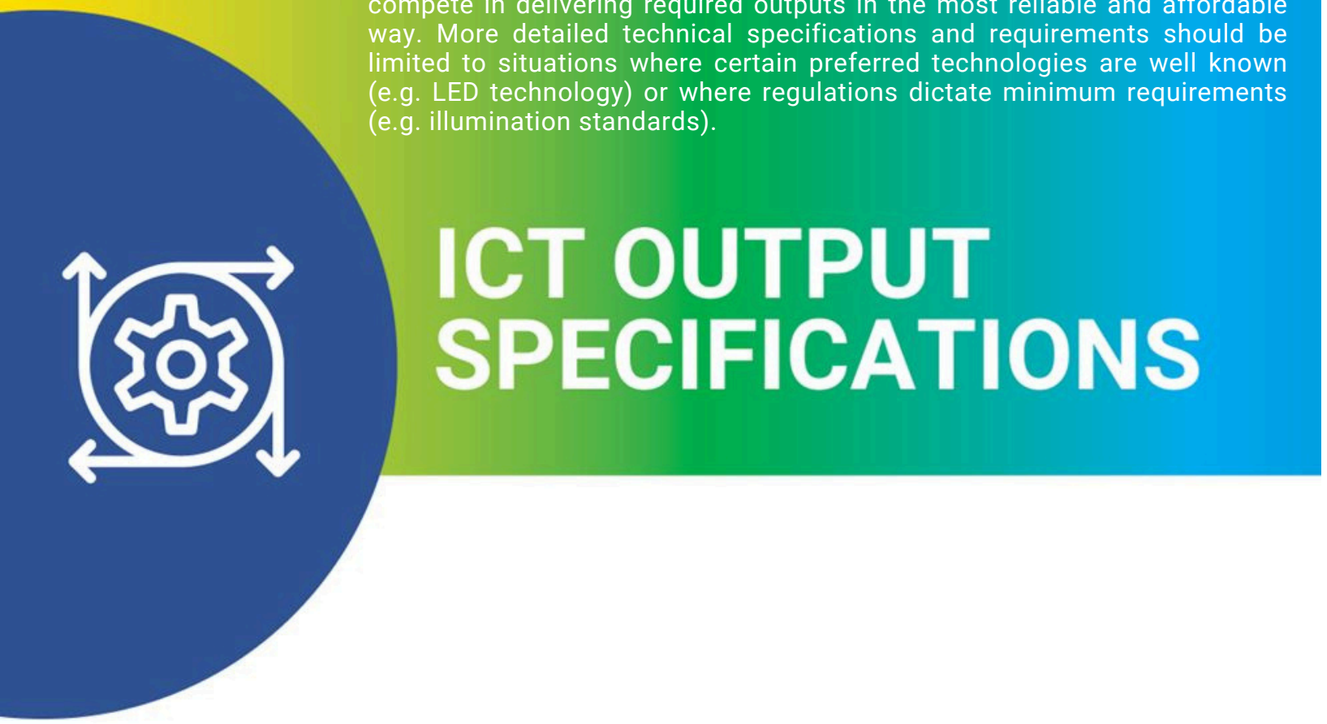
SWOT Analysis – other Smart City Services

Strengths	Weaknesses
1. Easy installation 2. Affordable 3. Long product life 4. Low power consumption 5. Connectivity agnostic 6. Valuable data insight	1. Large number required to see the bigger picture 2. Skilled workforce 3. Regulatory requirements for public disclosure
Opportunities	**Threats**
1. Improving citizen wellbeing 2. Sustainable urban planning 3. Actionable insights 4. Consolidated information repository 5. Crowdsourcing 6. Stakeholder engagement	1. Political uncertainty 2. Internal workforce to deliver expected project results 3. Project dissemination

3.4 Generic ICT Smart EPC concept and technology output specification - technical requirements for the implementation measures improving energy efficiency and standards in public lighting

Smart EPC output specification (i.e. technical requirements) represents an integral part of the Energy Performance Contract defining the technical requirements for the implementation of the measures for improving energy efficiency and standards that should be met by implementing additional energy and non-energy related services in public lighting system infrastructure.

When amending output specifications, Contracting Entities should try to avoid defining specific technologies if possible and should try to specify desired outputs of services in the form of required functionalities and quality of service. This should create surroundings for competitive tender procedure where different technologies and service providers would compete in delivering required outputs in the most reliable and affordable way. More detailed technical specifications and requirements should be limited to situations where certain preferred technologies are well known (e.g. LED technology) or where regulations dictate minimum requirements (e.g. illumination standards).



Smart EPC output specification (technical requirements) divided into four key parts (A, B, C and D) following the logic of development of the project

These parts differ according to the specific requirements in each phase (period) of the EPC contract duration:

PART A – minimum technical requirements and service standards (should be maintained in every phase of EPC contract implementation):
Minimum technical requirements and service standards are set for every phase of the duration of the EPC Contract. EPC service Provider is obliged to maintain them during the entire duration of the EPC Contract.

PART B – requirements in design and implementation phase:
Technical requirements for the design phase are set. It also defines the criteria for control of the developed design documentation and quality assessment of designed equipment. Design Phase commences immediately upon Contract signing, and lasts until the design documentation acceptance (after it has been examined).

PART C – requirements during the reconstruction and/or modernisation phase:
Technical requirements in the reconstruction and/or modernisation phase in accordance with the Energy Performance Contract are set. The Reconstruction and/or Modernisation Phase spans from the moment of approval of the design documentation to the moment of acceptance of the Measures for improving energy efficiency of the Public Lighting System. In addition to the technical properties and parameters, this part also sets out the procedures to be applied by the Contracting Entity and the Provider when checking the compatibility of the public lighting system with the technical requirements set out herein.

PART D – requirements during the use phase:
Technical requirements within the Use Phase in accordance with the Energy Performance Contract are set. The Use Phase shall start with the acceptance of the Measures for improving energy efficiency upon the end of Reconstruction and/or modernisation Phase and last until the Contract expiry and the transfer of ownership rights of the Measures for improving energy efficiency of the Public Lighting System to the Contracting Entity. The day of accepting the Measures for the improvement of energy efficiency shall be recorded in the Management and Control Centre (MCC) and from that day the measuring and verification of all contractual standards shall begin, i.e. the availability analysis and the fee calculation (done automatically via MCC).

3.5 Handbook on Smart City and other ICT technology in EPC - comprehensive overview of energy-efficient public lighting and financing models

Centralised guide for the energy and non-energy related services in public lighting and the basic steps for preparation and implementation of the Smart EPC project

HANDBOOK
SMART CITY & OTHER ICT TECHNOLOGY IN EPC

The preparation and implementation of the EPC project is a complex process that requires the expertise and experience of those who lead the project on behalf of the client (local authority). In view of the continuous progress of technology and equipment or innovation that takes place in terms of energy efficiency, **it is necessary to have consultants/experts familiar with the recent developments in the area (building/public lighting) in the process of project preparation and implementation, as well as having experience in preparation and implementation of procurement procedures for energy services.** It is important to ensure that technical specifications, conditions of procurement skills, contract proposals and required guarantees do not eliminate the economic entities (private companies) that are capable of implementing the project. Also, it is important to secure that the local authority obtains a quality solutions and equipment and to be secured from the risks it does not manage during the project. To enable this, procurement procedure and tender documents need to provide sufficient space for the interested entities to deliver a variety of innovative solutions. Such an approach enables the best value for the taxpayer's money to be realized, i.e. it is ensured that through the public procurement the local authority will achieve the purpose of the project in the best possible way.

Workflow for the preparation and implementation of the EPC project

Step 1. Project preparation

- incorporating an experienced consultant/expert to support the implementation of the entire project;
- analysing and defining client (local authority) needs and strategy of development for next 10 years;
- analysing Smart City applications and potential of implementing different solutions in the management of public services;
- analysing EV charging needs and potential;
- analysing existing data and the need for additional information (procuring detailed energy audit);
- analysing possible technical solutions - detailed analysis of different technical solutions, their technical applicability and the cost of technology;
- evaluating and confirming the economic and technical benefits of the Smart EPC model for the intended purpose - savings potential, forecasting investment volumes, forecasting possible additional revenue, etc;
- consulting with potential private entities and potential financiers of ESCOs - market analysis;
- developing initial business/financial plan of Smart EPC project – budget plan.

Step 2. Procurement of energy service providers

- drafting and defining a public procurement documentation and Smart EPC contract for the project;
- defining appropriate criteria for estimating the set of input data for contract documents;
- defining tender criteria to select the most economically advantageous offer/bid;
- selecting ESCOs based on the most economically advantageous offer.

Step 3. Signing an EP contract

- energy efficiency agreements are comprehensive, complex and balanced - they should be given full attention;
- some of the most important contract terms:
    - estimation of initial energy consumption - basic consumption,
    - definition of the guaranteed savings,
    - payment deductions due to unrealized savings,
    - termination fees and methodology how they are estimated,
    - method of measuring and verifying the realized savings,
    - risk allocations and contract guarantees.

Step 4. Implementing EPC Project

- completing the design documentation;
- applying agreed energy saving measures;
- detailed testing of equipment operation and acceptance of measures taken;
- training of personnel to handle the built-in equipment;
- setting up contract management procedures.

Step 5. Energy savings period; monitoring of delivered services and general assessment:

- ESCO is responsible for the efficient operation of the in-built equipment;
- realized savings are most often estimated annually;
- ESCO starts monthly (or maximum annual) monitoring of the measured values and controls deviations from the plan (the local authority controls);
- ESCO is obliged to compensate for the possible difference between guaranteed and realized savings (most often by reducing the contractual fee – unitary charge);
- the local authority controls whether the ESCO fulfils all the contractual obligations and verifies and pays the unitary charge if all the conditions are met.

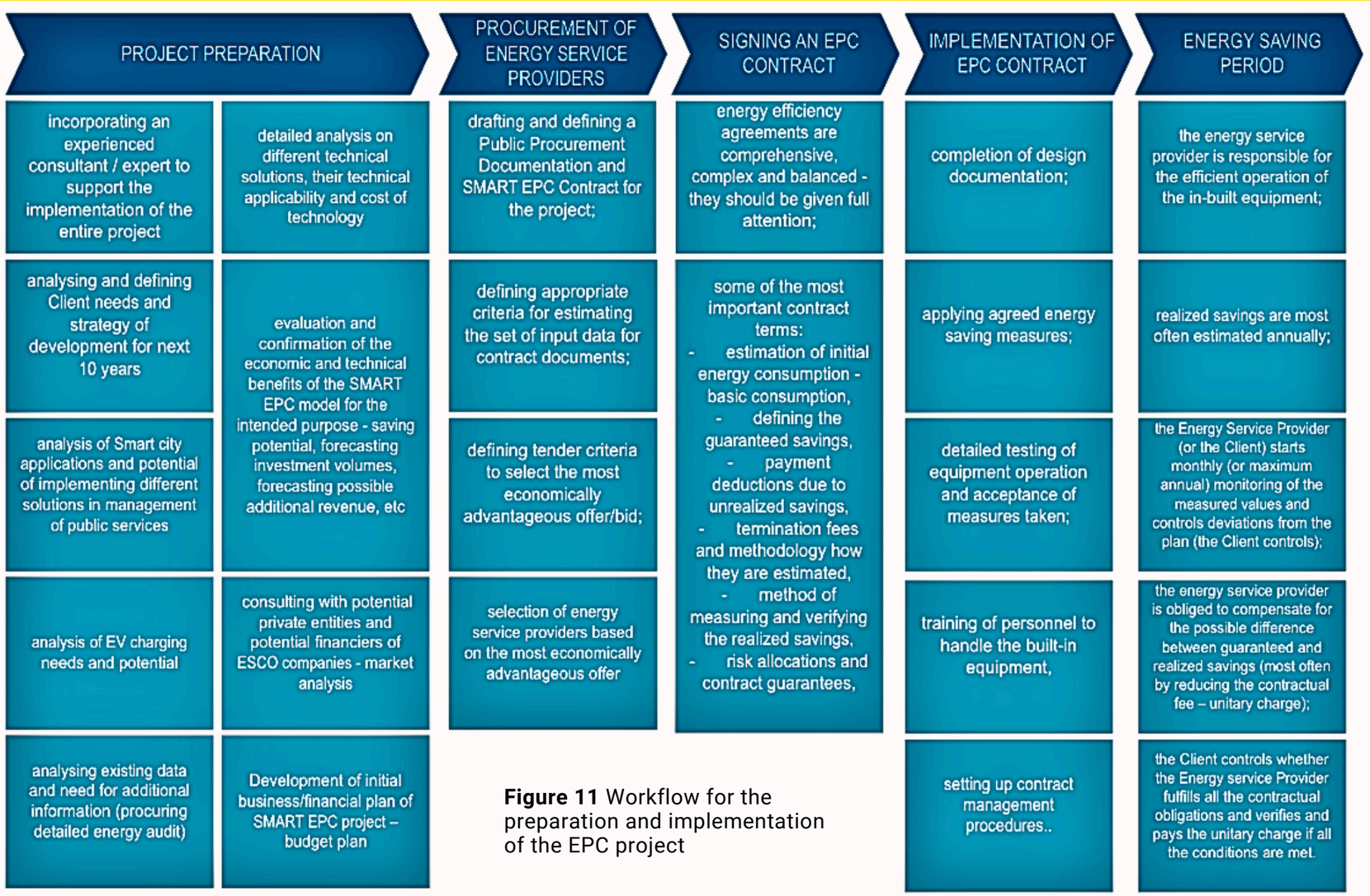


Figure 11 Workflow for the preparation and implementation of the EPC project

Possible problems/risks in the implementation of EPC projects

EPC projects are complex and, therefore, they have to be very carefully prepared. For the purpose of minimizing the problems in the preparation or implementation of EPC projects, it is necessary to engage consultants/experts in the EPC project at the beginning of the project. Therefore, it is recommended to hire an experienced consultancy firm to assist in project preparation by:

- developing documentation required for contracting;
- formulating recommendations for technical and commercial goals;
- coordinating the procurement process (call for tenders and selection of best offers);
- using its knowledge of the market to perform the technical and economic evaluation of tenders;
- performing or setting up a monitoring procedure for the contract implementation.

Constrains and specifics of EPC

Generally, some constraints and specifics of EPC projects can be highlighted:

- the EPC model is not universally applicable. Therefore, the assessment of the appropriateness of this energy reconstruction model for each individual building or infrastructure facility is one of the most important steps in the project preparation;
- the ratio of investment volume and potential savings is one of the key factors - a simple pay-back period should be between 6 and 12 years (usually about 10 years);
- generally speaking, the EPC model is not suitable for small buildings or small public lighting systems - the return on investment resulting from savings in operating costs is lowered to lower values for small buildings;
- Major building interventions (deep renovations) or major infrastructure upgrades (changing el. cables and lamp posts) are only possible if the local authority is ready to pay additional costs.

4. How to implement Smart EPC project?

Basic steps of preparation and implementation of the Smart EPC project

The Smart EPC concept (standardisation of the EPC), enables the bundling of smaller projects and turnkey solutions for potential investors, thus simplifying the procedures, facilitating additional investments in energy efficiency and reducing the energy efficiency gap. EPC documentation developed in Smart EPC project framework is in accordance with EUROSTAT rules to ensure off-balance treatment of the public lighting reconstruction projects. **The usage of standardised documentation proved to be a key success factor in attracting ESCOs to tender for small-scale projects since they could execute due diligence and make offers in a relatively short period.**

The preparation and implementation of the EPC project is a complex process that requires the expertise and experience of those who lead the project on behalf of the client (local authority). In view of the continuous progress of technology and equipment or innovation that takes place in terms of energy efficiency, **it is necessary to have consultants/experts familiar with the recent developments in the area (building/public lighting) in the process of project preparation and implementation, as well as having experience in preparation and implementation of procurement procedures for energy services.** It is important to ensure that technical specifications, conditions of procurement skills, contract proposals and required guarantees do not eliminate the economic entities (private companies) that are capable of implementing the project. Also, it is important to secure that the local authority obtains a quality solutions and equipment and to be secured from the risks it does not manage during the project. To enable this, procurement procedure and tender documents need to provide sufficient space for the interested entities to deliver a variety of innovative solutions. Such an approach enables the best value for the taxpayer's money to be realized, i.e. it is ensured that through the public procurement the local authority will achieve the purpose of the project in the best possible way.

All developed documents (Figure 12) help to standardise the process of project preparation as well as tendering and contract documentation. This helps local authorities to prepare projects that are standardised feasible, bankable and market ready. Standardized Smart EPC documentation is developed in format that enables local authorities to tailor it to their specific needs while remaining uniformity and standardised contract stipulations.

Standardised documentation created within the Smart EPC project includes:

a. Standardised methodology for conducting a detailed energy audit of public lighting system;
b. Standardised methodology for selection of lighting classes according to CEN/TR 13201-1:2014;
c. Analytic tool for assessment of reconstruction potentials and financial modelling for ensuring that innovative energy services are reliable and verifiable and that ESCOs are trustworthy and accessible;
d. Action plan for the reconstruction of public lighting system (a document used to present the current state of infrastructure and reconstruction potentials, as well as the optimal territorial coverage of actions and financial modelling primarily for local authority representatives and bodies);
e. Standardised Smart EPC contract with all relevant addendums (such as standardised technical requirements, measurement and verification methodology based on Smart IT solutions and metering (MCC), a draft of financial models/tables etc.) for integration of energy and non-energy related services;
f. Tender documentation (for open and restricted procedures) that includes all needed addendums.

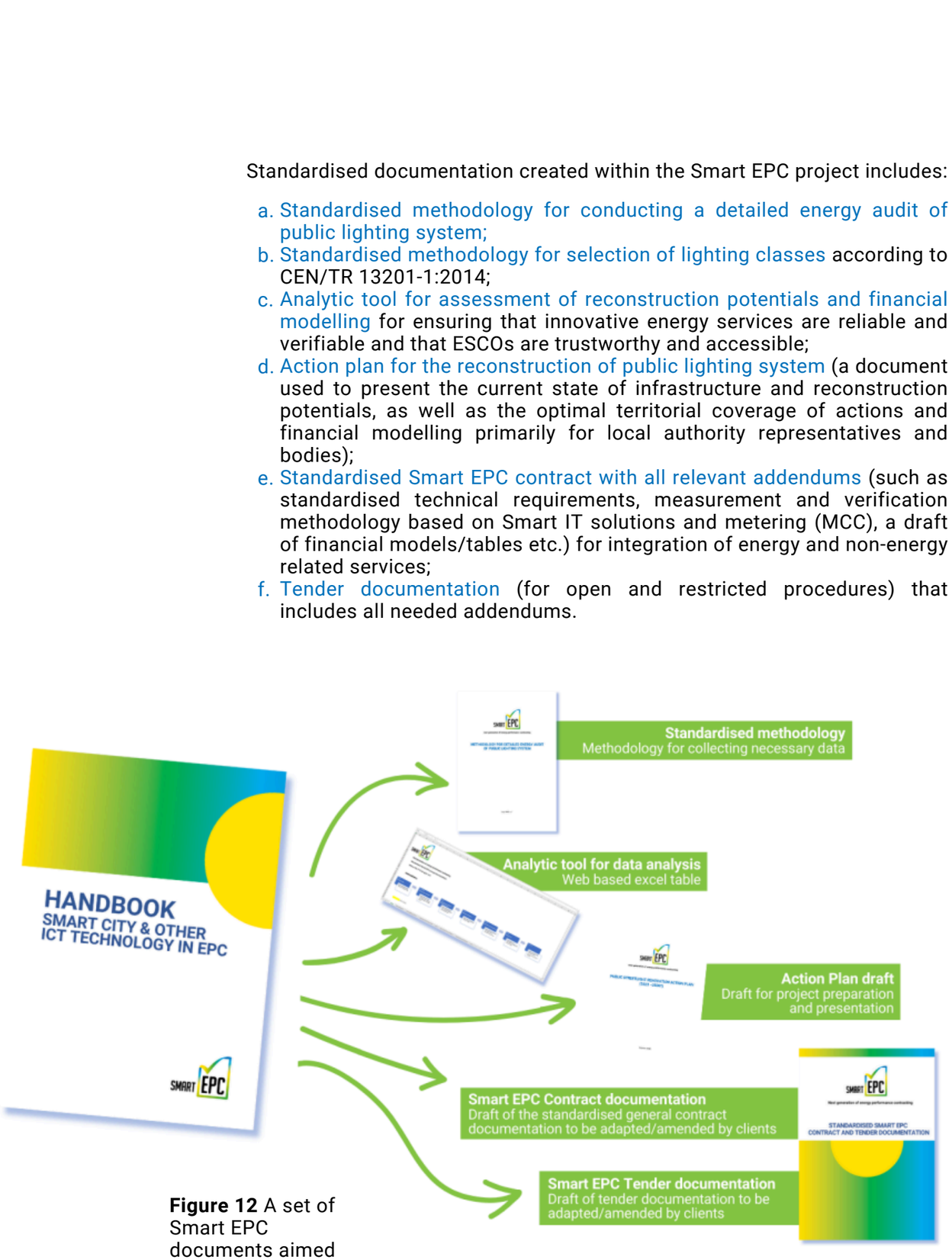


Figure 12 A set of Smart EPC documents aimed at project development

Smart EPC concept documentation

Standardised SMART EPC concept documentation is relevant for inventory data collection and analysis of the public lighting system. The purpose of the concept documentation (Figure 13) is:

1. to formulate the requirements for the energy audit (minimum set of baseline data that is needed for decision making and feasibility calculations of public lighting reconstruction) – requirements summarized in Standardized Methodology for detail energy audit of public lighting and methodology for selection of lighting classes;

2. to develop an analytic tool for feasibility calculation of public lighting reconstruction based on the inputs from the detail energy audit – tabular based tool in Analytic tool;

3. to draft document which can serve as a tool for presenting the current state of infrastructure and reconstruction potential, as well as the optimal coverage and financing modelling for cities/municipalities – draft and content example in Public lighting reconstruction Action plan;

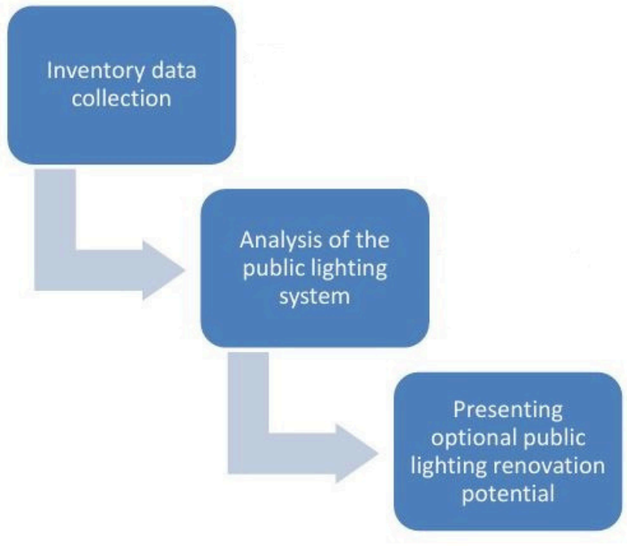


Figure 13 Smart EPC concept documentation flowchart

4.1 Standardised methodology for detailed energy audit of public lighting system

SMART EPC

next generation of energy performance contracting

METHODOLOGY FOR DETAILED ENERGY AUDIT OF PUBLIC LIGHTING SYSTEM

A standardized set of data enables easy comparison amongst different projects as well, enabling potential service providers to easily check all technical inputs in the project and prepare their bids.

Standardised methodology prescribes minimum levels of detailed data that needs to be collected, which helps to reduce risks and uncertainties in project development and later on in project realization – fewer risks/ uncertainties lead to lower EPC fees.

Data that needs to be collected are divided into two main groups (Figure 14). First set of data needs to be collected for EPC contract implementation. Second set of data is data that serves as additional data that is not obligatory to collect and is used for checking the quality in later stages of energy audit or EPC contract. First set of data is obligatory for collecting (without this data EPC is not possible) while second set of data is just recommendation.

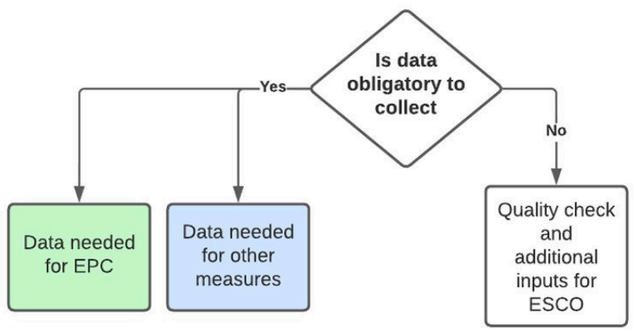


Figure 14
Different sets of data description

Methodology for collecting all necessary data about the public lighting system needed to perform technical and financial analysis of the project

The main goal of the public lighting energy audit is to collect all the necessary data for:

- modernization of the public lighting system through the Energy Performance Contract;
- implementation of non-revenue related measures (smart city);
- implementation of additional revenue-based services like e-charging or 5G;
- implementation of the measures for light pollution protection.

The purpose of the Methodology is to formulate the requirements for the energy audit by proposing the procedure and the minimum set of baseline data that is needed for decision making and feasibility calculations of public lighting reconstruction.

Some countries defined obligation of producing an energy audit of public lighting by law (e.g. Croatia), but this Smart EPC Methodology is not part of the legislative framework and it is suggested that Smart EPC Methodology needs to be adjusted to national or local legislation framework (if existing).

Figure 15 shows the basic phases of the implementation of a detailed energy audit of the public lighting system.

Public lighting owner/operator has the right to supervise the implementation of any energy audit phases. After the completion of the last phase and before the printing and submission of the Report, the public lighting owner/operator has the right to review the completeness and accuracy of the collected data. If it turns out that the data are not complete and/or accurate, the energy auditor is obliged to supplement them at his own expense in order to meet the requirements specified in this Methodology.

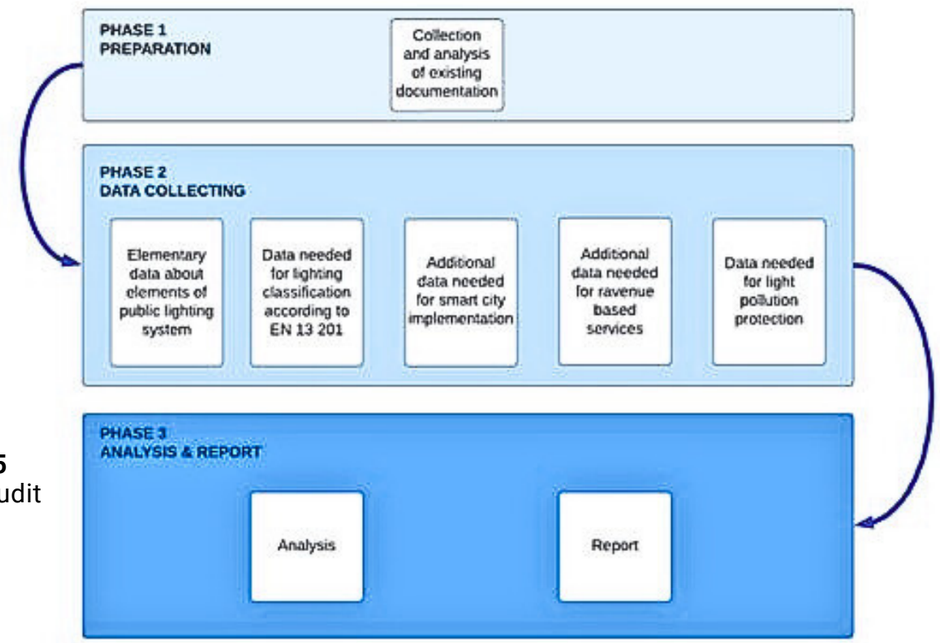


Figure 15
Energy audit phases

4.2 Analytic tool for data analysis - web based excel table

An analytic tool in the form of an Excel table helps clients to analyse easily feasibility of the project by calculating potential energy savings in five steps (Figure 16).

Energy savings (savings in energy costs) will define the potential for capital expenditure and operating costs that can be financed from future energy savings.

Energy savings vary depending not only on the changing source of lighting (old lamps vs LED technology) and the management of public lighting (dimming regimes, automatic dimming, etc.).

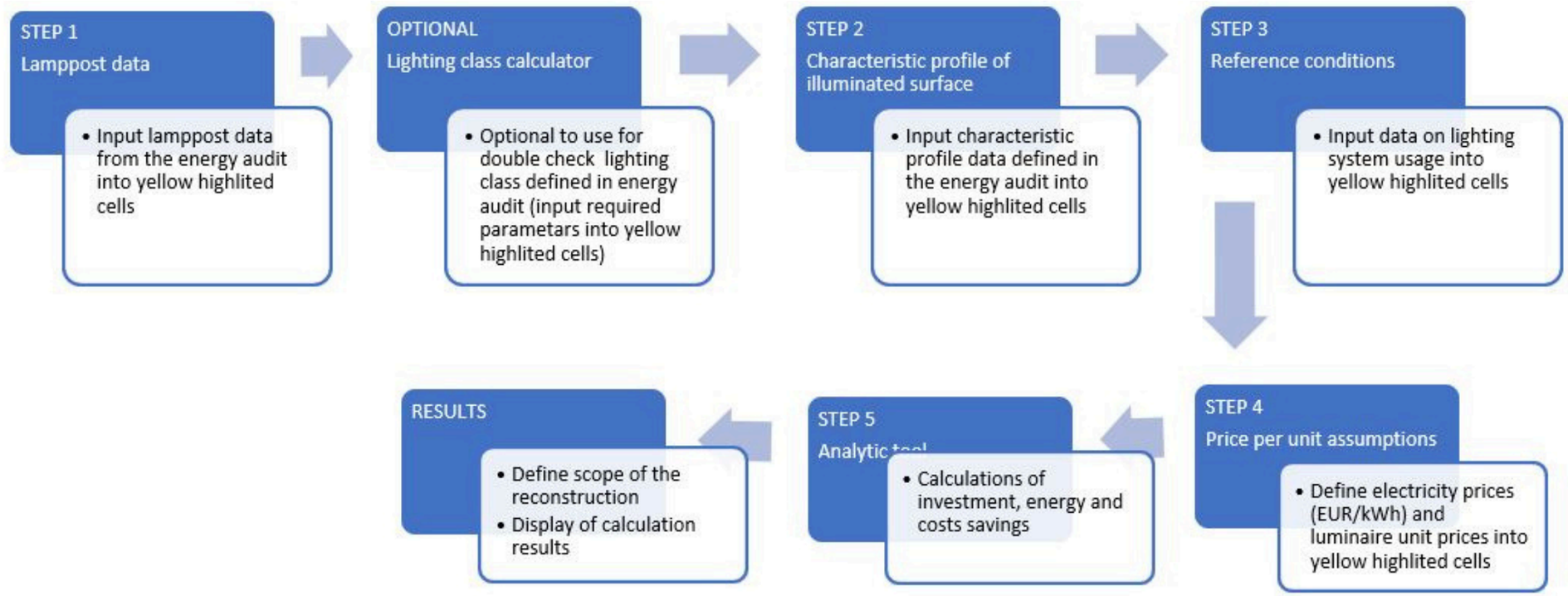


Figure 16 Steps needed to define the scope and energy savings potential of public lighting reconstruction

4.3 Action Plan draft for public lighting renovation project preparation and presentation

SMART EPC

next generation of energy performance contracting

PUBLIC STREETLIGHT RENOVATION ACTION PLAN (2023 –2030?)

Public lighting renovation action plan (Action Plan) is the key strategic document used to analyse the current state of infrastructure and renovation potential, as well as the optimal coverage and models of public lighting financing.

The Action Plan is a document which indicates a method for artificial lighting of roads, parks and other public areas with the purpose of meaningful planning of construction and renovation of the public streetlight system and represents a strategic document of the local authority in terms of developing the public lighting system in the period till 2030 (or further) and supporting the climate neutrality targets for 2050 by significantly reducing the energy demand.

In order to encourage concrete steps by member states (national, regional and local levels), the European Commission supports public and private investments in projects that contribute to the stated goals through initiatives and funds. The action plan represents the continuation of the adoption of strategic and planning documents of the City/Municipality for the purpose of planning specific sustainable development activities. **The purpose of the Action Plan is to define the total needs of the City/Municipality in order to ensure the full functionality of the public lighting system and the optimal model of financing the necessary activities.**

Defining the optimal scope and financing model

As a part of the Action Plan, the analysis of the existing situation of the public streetlight system is done for the purpose of defining the overall construction and upgrade needs, renovation potential and method for infrastructure operation and management. It is made based on the collected and processed data from the conducted energy audit of the public lighting system, which cover the entire system infrastructure. In addition to the technical aspects, the analysis of the maintenance and construction of the public lighting system, as well as the energy balance of the electricity consumption is carried out.

The existing public lighting system could be in a relatively good condition due to good management and regular maintenance, but mostly technologically outdated and energy inefficient. The Action Plan presents potentials of renovation in terms of energy and cost savings. It should be emphasized that, **apart from the renovation of existing luminaires, the technical solutions proposed by the Action Plan also include additional renovation with the aim of achieving the current lighting standards** (minimum light technical parameters in accordance with norm EN 13201) as well as renovation for the purpose of the alignment with the legislative framework of light pollution limitations. The Action Plan provides an optimum coverage of the financial model of construction, extension and renovation.

Analysing the maintenance and renovation activities of the public lighting system that the local authority will definitely have to undertake, it is evident that some overlap and that it is desirable and rational to coordinate them in order to optimize the process and not to duplicate certain costs (Figure 17).

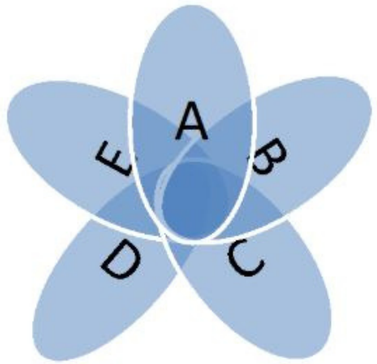


Figure 17
Overall needs and possibilities of public lighting renovation

Smart EPC contract and tender documentation

The successful preparation and execution of Energy Performance Contracting (EPC) projects require the expertise and experience of project leaders representing the local authority or client. As technology and innovations in energy efficiency continue to progress, it becomes imperative to engage consultants and experts well-versed in the latest developments in the field of building and public lighting. These specialists play a crucial role in project preparation, implementation, and procurement procedures related to energy services.

A key aspect of these projects is to ensure that the technical specifications, procurement conditions, contract proposals and required guarantees do not exclude competent private companies capable of effectively executing the project. Additionally, it is vital to safeguard the local authority from unanticipated risks that may arise during the project while ensuring the delivery of high-quality solutions and equipment. This approach promotes an open procurement procedure that encourages interested entities to offer innovative solutions, thereby maximizing the value for taxpayers' money and achieving the project's objectives efficiently through public procurement.

When incorporating additional energy and non-energy related services into the Smart EPC approach, the complexity of standard EPC projects is further highlighted. These projects involve the realization of various types of investments under a single contract, posing challenges in accounting, financing and legal aspects. To address these complexities and assist cities in developing such projects, the Smart EPC project has developed standardized Smart EPC contract and tender documentation. This documentation provides a comprehensive draft of the contract and its annexes, which can be easily adapted to suit the unique requirements of each client.

The SMART EPC contract documentation is built upon the foundation of standard EPC contract documentation, with a focus on energy performance and guaranteed energy savings as the core subjects. **The additional energy and non-energy services are categorized as either commercial or non-commercial services.** The former can be financed by charging for the services to third parties or the general public on a commercial basis. In contrast, the latter may not be feasible through commercial financing and are usually included within the contract. These distinctions result in different types of investments for the client, with non-commercial investments considered as "on balance sheet" and commercial ones often treated as "off balance sheet."

To ensure clarity and fairness in the tendering process, the Smart EPC contract documentation specifies a fee or revenue that service providers must pay for the right to use public lighting infrastructure to provide commercial services to the public. This fixed fee can be easily quantified in the tender documentation, although clients have the option to consider variable fees based on a percentage of total revenue from commercial services. Decisions regarding these approaches are typically made after thorough workshops with potential service providers before the official tender launch.

Figure 18 Smart EPC contract and tender documentation

4.4 Smart EPC contract documentation

Next generation of energy performance contracting

STANDARDISED SMART EPC CONTRACT AND TENDER DOCUMENTATION

The main purpose of Smart EPC Contract is the reduction of the installed power of the Public Lighting System, reduction of energy consumption, reduction of greenhouse gas emissions, limitation of light pollution, and the improvement and guaranteeing of the minimum and maximum level of illumination of public areas in accordance with the regulations in force.

Additional purpose of Smart EPC contract is to provide additional non-energy efficiency services to Contracting entity and to third parties on commercial and non-commercial basis (public services).

By this Contract, the Provider uses its skills and innovation in order to provide the Contracting Entity with an energy service by implementing and applying the Measures for improving energy efficiency of the Public Lighting System in a cost-efficient manner, simultaneously maintaining or increasing the current public lighting service and quality standard.

Smart EPC contract documentation for an open procurement procedure

The standardised Smart EPC contract documentation encompasses various annexes that provide detailed information essential for project implementation. These include:

- SMART EPC Contract Draft: Outlining the general provisions of the SMART EPC contract;
- Annex 1: Project Scope: Describing the Contracting Entity's overall public lighting system, including information on lighting classes, elements of the system, and the proposed Measures for improving energy efficiency. –(empty template – users need to specify their project scope);
- Annex 2: Public Lighting System Reference Condition: Presenting reference data for the public lighting system before implementing energy efficiency Measures, enabling the identification of energy and cost savings. (empty template – users need to specify their reference data);
- Annex 3: Technical Requirements: Defining the technical standards for implementing energy efficiency Measures and additional energy and non-energy services, divided into different phases of contract execution (ICT SMART EPC Concept draft output specification);
- Annex 4: Monitoring, Measurement, and Verification Plan: Detailing the plan for monitoring, measuring, and verifying energy savings, along with fee adjustment procedures and specifications for measuring devices;
- Annex 5: Content of the Report, Agreement, and Records: Providing templates for reports, agreements, and records for specific phases of the contract's duration;
- Annex 6: Tender: Including the Tenderer's tender, which becomes part of the contract upon selection. (empty – to be included upon selection of winning tender);
- Annex 7: Investment Value: Comprising tables integral to the tendering documentation, including the Investment Value, Structure of Financing, and Amortization Plan. (empty predefined excel table for tenderers to fill);
- Annex 8: Payment Plan and Savings Plan: Presenting an excel table for tenderers to fulfill, including the Reference Condition, Input Data, Fee Payment Plan, and Savings Plan. (empty predefined excel table for tenderers to fill);
- Annex 9: Plan of Implementation: Defined in the Tenderer's (Provider's) Tender, outlining the execution of Measures for improving energy efficiency. (empty – to be included upon selection of winning tender).

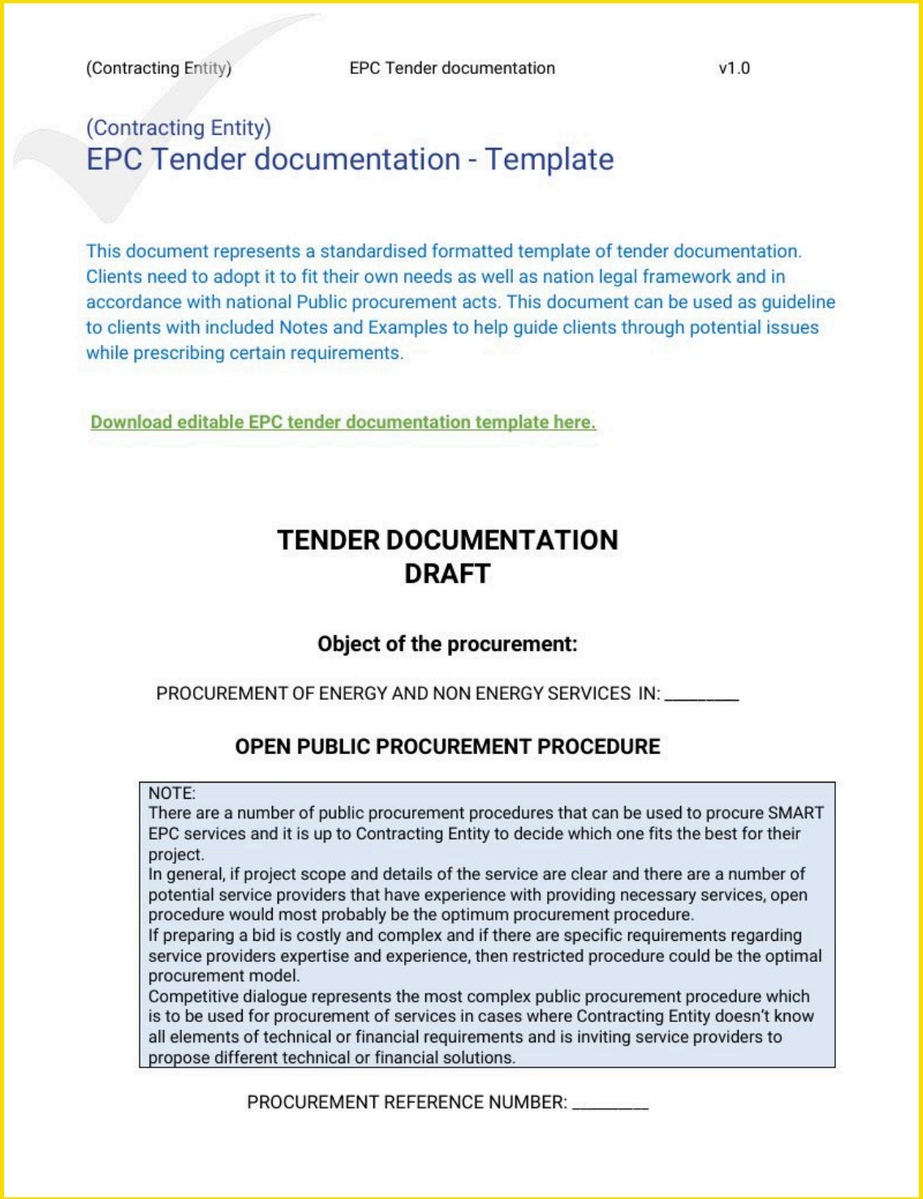
4.5 Smart EPC tender documentation

Next generation of energy performance contracting

STANDARDISED SMART EPC CONTRACT AND TENDER DOCUMENTATION

In addition to the standardized draft of Smart EPC contract documentation, the project has also developed standardized Smart EPC tender documentation. This draft serves as a guideline document for clients when preparing official tender documentation, offering insights on how to specify certain requirements and considerations to be mindful of while doing so. The standardized tender documentation needs adaptation to comply with specific national legal frameworks and project requirements (Figure 19).

Smart EPC tender documentation for an open procurement procedure



(Contracting Entity) EPC Tender documentation v1.0

(Contracting Entity)

EPC Tender documentation - Template

This document represents a standardised formatted template of tender documentation. Clients need to adopt it to fit their own needs as well as nation legal framework and in accordance with national Public procurement acts. This document can be used as guideline to clients with included Notes and Examples to help guide clients through potential issues while prescribing certain requirements.

Download editable EPC tender documentation template here.

TENDER DOCUMENTATION
DRAFT

Object of the procurement:

PROCUREMENT OF ENERGY AND NON ENERGY SERVICES IN: _____

OPEN PUBLIC PROCUREMENT PROCEDURE

NOTE:
There are a number of public procurement procedures that can be used to procure SMART EPC services and it is up to Contracting Entity to decide which one fits the best for their project.
In general, if project scope and details of the service are clear and there are a number of potential service providers that have experience with providing necessary services, open procedure would most probably be the optimum procurement procedure.
If preparing a bid is costly and complex and if there are specific requirements regarding service providers expertise and experience, then restricted procedure could be the optimal procurement model.
Competitive dialogue represents the most complex public procurement procedure which is to be used for procurement of services in cases where Contracting Entity doesn't know all elements of technical or financial requirements and is inviting service providers to propose different technical or financial solutions.

PROCUREMENT REFERENCE NUMBER: _____

Figure 19 Smart EPC tender documentation template

Smart EPC contract and tender documentation adapted to national conditions of pilot countries

The contract development and tendering procedures are different in the partner countries (Figure 7) with some **common rules and national specific procedures**; therefore, the partners had to adapt them for each country.

In **Spain (Murcia and Rivas)**, an EPC model is planned to be utilized, with the ESCO or municipal personnel undertaking the primary tasks, under the supervision of the municipality. The following national conditions have been highlighted:

- The acquisition, installation (with or without maintenance) and integration of lighting and smart services has been framed as a comprehensive service package.
- Lamp and smart device acquisition is included in municipal tenders. Installation can be managed by municipal personnel or maintenance companies (Rivas approach for specific devices like video cameras).
- Essential project data (technologies, areas, timelines, light point inventories) are gathered to create detailed technical documentation. Include inventory results as an annex to Smart EPC documentation.
- Data control and programming for energy savings and efficiency are emphasized.
- The potential for reducing lighting intensity during off-peak hours (as implemented in Rivas) is analysed.
- The option of longer-term contracts (8-12 years) has been chosen, with maintenance being optional and provided by external entities or the ESCO.

Figure 20 Smart EPC pilots distribution

In **Poland (Krakow and Warsaw)**, the preparatory phase for pilot projects considered the existing experience of each city in delivering energy-efficient lighting solutions. There are differences between Warsaw and Krakow that may have influenced the approach to implementing Smart EPC solutions:

- Warsaw's near-complete LED public lighting system conversion limits opportunities for new Smart EPC contracts using the EPC, focusing instead on integrating smart sensors for additional public services.
- Krakow's tender will utilize an EPC, with a private contractor responsible for energy efficiency measures and smart sensor integration into existing systems and new horizontal control systems.
- Both Warsaw and Krakow's approaches leverage smart sensors to enhance functionalities and public services, demonstrating a commitment to technological advancements in street lighting.
- A key consideration for both cities is retaining day-to-day management control of their public lighting systems to effectively address citizen needs and maintain responsiveness.

In **France (Auvergne Rhone-Alpes region)**, new master planning documents for public lighting renovation projects are being developed, known as SDALs (Schémas Directeurs d'Aménagement Lumière). These documents, which are not currently compulsory, extend the scope of traditional public lighting renovation projects by incorporating new recommendations:

- Moved beyond basic public lighting renovations, incorporating factors like biodiversity impact and user needs.
- The use of LED and smart lighting technologies wa promoted, aiming to reduce the number of light points and electrical cabinets, thus improving efficiency.
- Mandated studies to understand the lighting needs of diverse user groups (e.g., cyclists, pedestrians, shopkeepers), ensuring the lighting design caters to their specific requirements.
- Required assessments of ecological areas and protected species to minimize the negative impact of lighting on local biodiversity.
- The increasing cost of loans might lead to more French local authorities considering leasing options for public lighting projects, requiring adjustments to existing standardized documentation.

In **Croatia (Karlovac)**, the market for additional energy and non-energy services is underdeveloped and immature, creating significant risks for service providers:

- Blending energy and non-energy services with energy efficiency services in a single contract remains challenging unless services are directly linked (e.g., smart lighting management).
- A commercially viable business case is difficult to establish for many non-energy services due to market immaturity.
- One solution is for the contracting authority to fund implementation and assume the monetization risk of additional services.
- An alternative is a partnering approach where the service provider develops and implements additional services, bearing all risks but sharing potential revenue/profit with the contracting authority.

Feedback obtained on the adapted Smart EPC standardized documentation

Smart EPC stakeholders provided various feedback on the adapted Smart EPC documentation during **public consultations and workshops** across the pilot countries. Here are the key points of feedback:

Spain:

- Stakeholders emphasized the need to define clearly and concisely the required lighting values, citing examples of municipalities that were poorly lit due to establishing low lighting levels.
- Establishing an energy price based on historical prices that accounts for price variability due to geopolitical situations was suggested.
- Technical feedback reinforced the approach of maintaining centralized point-to-point control through electrical panels.
- In Rivas, stakeholders noted that EV charging integrated in lamp posts was not feasible due to power intensity limitations.
- Companies confirmed that 5G technology implementation was not possible in Rivas at the moment due to lack of supporting devices.

Figure 21
Smart EPC pilot in Croatia

Poland:

- Market representatives emphasized that all ordered systems should be based on open data exchange protocols.
- Stakeholders requested clear definition of whether smart services would be mandatory elements that contractors must implement.
- The need to precisely define requirements for historical luminaires for proper budgeting was highlighted.
- Telecommunications operators expressed interest in 5G network services, though noted that free frequencies were not available in Poland.
- Technical feedback recommended using lighting fixtures with Zhaga D4i certification and systems that integrate multiple lighting fixture manufacturers.

France:

- Energy syndicates expressed reluctance to use Performance-based Global Markets (PGMs) in public lighting, as they preferred to retain control over technical specifications and site monitoring.
- It was noted that penalties in the standard documentation were too strong, which could discourage companies from bidding.
- It was indicated that including electricity supply in global contracts was problematic due to difficulties in providing revision formulas applicable over long contract durations.
- Workshop participants highlighted the need for new planning documents (SDALs) that incorporate biodiversity concerns and adaptation to specific population needs.

Croatia:

- During the first public consultation, stakeholders submitted 54 questions, mostly seeking clarification on technical details.
- Economic operators requested more detailed technical data for lighting calculations (road width, pole spacing, etc.).
- Questions were raised about installation and data transmission costs for sensors/actuators on certain lamps.
- The city partially accepted many suggestions, providing detailed justifications for each decision to balance technical feasibility and procurement fairness.
- Some suggestions were fully accepted, such as removal of certain connection requirements and addition of historical electricity price tracking.

Overall, the consultations revealed that while the core Smart EPC framework provides a solid foundation, successful implementation requires flexibility to accommodate national legal frameworks, market conditions, technical realities and administrative practices.

5. Smart EPC pilot projects key achievements

Step-by-step approach to public lighting modernization through EPC in Karlovac (Croatia)

The Karlovac Smart EPC pilot demonstrates a pragmatic, phased approach to public lighting modernization in a medium-sized Croatian city. With limited financial and administrative resources, Karlovac prioritized the replacement of traditional public lighting with energy-efficient LEDs as a foundation for future Smart City integration. The project began with a detailed technical audit and feasibility study, followed by two rounds of public consultation to refine the scope and engage market stakeholders. The city adopted open standards to ensure future interoperability and scalability. While advanced smart services (like smart controls and EV charging) are planned for subsequent phases, the initial focus was on establishing a robust, standardized infrastructure. Karlovac's experience highlights the effectiveness of gradual implementation, stakeholder engagement and standardization, providing a replicable model for cities seeking to maximize energy efficiency and prepare for future Smart City upgrades within existing resource constraints.

Activities performed

- Enhanced audit and feasibility: The city identified data gaps in its initial audit and commissioned a more detailed assessment, followed by a feasibility study to define the optimal scope for modernization.
- Stakeholder engagement: Two rounds of public consultations were held with financial sector representatives and potential service providers, ensuring transparency and market readiness.
- Procurement and contracting: By September 2023, Karlovac had completed a public procurement process and signed an EPC contract with the selected ESCO (energy service company).
- Implementation: The project focused on city-wide LED replacement as the foundation for future smart system integration. By November 2024, the reconstructed lighting system had achieved conditional acceptance, pending minor software corrections.

Integrating real-time data for lighting management and adapting smart technology solutions to meet the specific needs of smaller municipalities in Auvergne Rhone-Alpes (France)

The French Smart EPC pilots, coordinated by Syane, demonstrate a multi-level approach to public lighting modernization. The flagship project in Evian-les-Bains involved renovating 2.700 luminaires, achieving 1.900 MWh in annual energy savings, and deploying a hypervision platform for centralized monitoring. Other municipalities focused on targeted smart upgrades or digitalization, integrating sensors and remote management systems. The French experience underscores the importance of regional collaboration, flexible contract models (CREM), and the coexistence of heritage conservation with smart technologies. Standardization and interoperability were prioritized, enabling future integration of services like WiFi, 5G and environmental monitoring. The pilots confirm that public lighting can serve as a backbone for broader Smart City services.

Activities performed

- Audit and feasibility: Conducting detailed audits of the existing public lighting system and performing feasibility studies to define the optimal scope of modernization for each municipality, including the integration of energy and non-energy services.
- Stakeholder engagement: Defining project requirements and incorporating other feedback from workshops and consultations, especially regarding biodiversity, heritage conservation and user-specific lighting needs.
- Procurement and contracting: Adapting the Smart EPC standardized tender and contract documentation to fit the French legal, administrative and technical context. Launching public tender with clear technical and performance requirements, including energy savings guarantees and integration of smart services.
- Implementation: Renovation of 2.700 luminaires in Evian-les-Baines, deployment of public lighting sensors and a hypervision platform for centralized monitoring and control.

Innovative solution for EV charging stations in Krakow (Poland)

The Krakow Smart EPC pilot centres on the modernization of public lighting through the replacement of 8.582 sodium luminaires with energy-efficient LEDs and the integration of smart services. Managed by the Public Roads Authority (ZDMK), the project includes a dynamic lighting control system, air pollution sensors, and pilot EV charging stations on selected lamp posts. The implementation is staged: first outside conservation areas (with air quality sensors), then in heritage zones (with EV chargers and more sensors). The project is expected to deliver a 75% reduction in energy consumption, significant CO_2 savings and a payback of just over six years. The approach emphasizes regulatory compliance, stakeholder engagement and adaptability, with the dynamic control system ensuring modern, flexible lighting management and reduced light pollution.

Activities performed

- Inventory assessment, energy audit and technical documentation preparation
- Stakeholder workshops, resident surveys, contract drafting and financing arrangements

Planned implementation in two stages:

Stage I: Replacement of lighting outside conservation areas with control systems and air quality sensors
Stage II: Replacement of lighting in conservation areas with EV chargers and additional sensors

Modernizing public lighting in historical areas in Warsaw (Poland)

The Warsaw Smart EPC pilot focuses on decarbonizing public lighting system while respecting the city's heritage context. The project involves replacing a reduced number of luminaires (due to prior large-scale LED upgrades and heritage constraints) with modern, efficient LED fixtures in parks and historic areas. The process required extensive coordination with heritage authorities to approve fixture designs and installation plans. The pilot also included a thorough inventory and energy audit, public communication and the preparation of a tailored tender for 1.363 new LED luminaires. The project demonstrates a replicable model for balancing energy efficiency, smart technology integration and historic preservation in urban lighting.

Activities performed

- Strategic planning: A detailed concept for lighting modernization was developed as part of the Smart EPC project, laying the groundwork for technical, administrative and heritage-related requirements.
- Stakeholder engagement and compliance: The project involved close coordination with the Mazovian Voivodeship Conservator of Monuments, the Capital Conservator of Monuments and the Department of Public Space Development to ensure that new lighting fixtures would be suitable for Warsaw's historic streets and parks. Formal decisions were obtained specifying the acceptable forms for modernized lighting infrastructure in protected areas.
- Technical assessment: A thorough inventory and energy audit of the lighting infrastructure targeted for modernization was completed. This provided the baseline data necessary for effective planning and tendering.
- Public communication: A dedicated project page was launched on the Municipal Roads Authority's website to inform the public and stakeholders about the project's progress.
- Tender preparation and launch: All necessary documentation was prepared for the procurement process. A tender was announced for the modernization of lighting, specifically for the delivery and installation of 1.363 new LED luminaires in 19 city parks.

Bundling smart lighting management, environmental monitoring and urban mobility infrastructure in Murcia (Spain)

Murcia's Smart EPC pilot is a large-scale initiative targeting both energy efficiency and Smart City readiness. The project includes the replacement of 6.507 HPSV luminaires with LEDs across five urban zones, and the installation of 1.263 solar-powered LED luminaires along bike and pedestrian lanes. Smart features include motion, traffic and weather sensors, centralized remote management and pilot EV charging points integrated into lamp posts. The project required adaptation to national and local regulations and was structured to ensure technical and financial feasibility. Murcia's approach highlights the importance of aligning ambitious Smart City goals with practical constraints, careful planning and phased implementation to maximize both sustainability and operational benefits.

Activities performed

- Energy performance contracting (EPC): The project centres on the preparation and tendering of an EPC model contract to drive energy efficiency and integrate smart services into public lighting.
- LED modernization: Replacement of 6.507 luminaires, primarily high-pressure sodium vapor (HPSV) units, with LED technology, distributed across five key zones: Murcia centre, El Esparragal, Guadalupe, Sangonera, and Campo de Murcia.
- Solar lighting: Installation of 1.263 solar-powered LED luminaires along bike and pedestrian lanes in five additional areas (Vía Verde, Río Noreste, Río Noroeste, Río Sureste, and Río Suroeste), supporting sustainable mobility and off-grid lighting.
- Smart sensors and controls: Deployment of motion sensors, traffic detection sensors and weather sensors to enable adaptive lighting and data-driven management.
- EV charging infrastructure: Installation of five EV charging points integrated into lamp posts, piloting the use of public lighting infrastructure for e-mobility services.
- Remote management: Implementation of centralized management and remote control at both the cabinet (via 5G or optical fibre) and luminaire level (via PLC), enhancing operational efficiency and enabling real-time monitoring.

Integration of lighting management, control, regulation and smart solutions using the electric power network in Rivas (Spain)

The Rivas Smart EPC pilot leverages an already modernized LED lighting infrastructure, shifting focus from fixture replacement to smart integration and control. The municipality enhanced its UVAX system to connect all luminaires for comprehensive monitoring and adaptive lighting. Smart services introduced include WiFi antennas, video analytics for presence detection in sports courts and small-scale EV charging for e-mobility. Rivas emphasized robust data management, stakeholder engagement and future-oriented planning, including market consultations for 5G integration. The pilot demonstrates how municipalities with existing LED infrastructure can continue to advance energy savings and urban services through smart controls and incremental upgrades, maximizing the value of prior investments.

Activities performed

- Inventory development and data management: The municipality improved its database system by incorporating and correlating Smart EPC data for all Control Management Boards (CM) and lighting points, ensuring comprehensive information for each component.
- Smart services integration: Rivas identified and implemented several smart services including WiFi antennas, video cameras functioning as presence sensors in sports courts, people counting systems, safety buttons and explored EV charging capabilities.
- Control system enhancement: The municipality connected all luminaires to the existing UVAX system to enable comprehensive monitoring and control of the entire lighting network.
- Stakeholder engagement: Rivas hosted a workshop with national partners, ESCO companies and technology providers to demonstrate their smart lighting services and discuss contract models. The workshop concluded that flexibility is essential for adapting and incorporating innovative technologies.
- EV charging exploration: Despite identifying a viable low-capacity lamp post-integrated charging solution, Rivas was unable to secure a manufacturer to supply units for their pilot due to availability constraints.
- Future-oriented planning: As their current ESCO contract concludes in 2028, Rivas has already initiated market consultations with major Spanish operators regarding dedicated 5G SA (Standalone) services. This forward-looking approach aims to enhance their network infrastructure with potential speeds up to 1 Gbps, significantly improving their current B-PLC protocol system that maxes out at 100 Mbps.

Financing models used during Smart EPC pilots implementation

The role of the investor varied depending on the country, the specific city/municipality, and whether the pilot followed an EPC-based model or not.

Spain:

Murcia:

- The pilot is in preparation with Signify, Schreder and UVAX Concept SL listed as potential suppliers.
- The municipality, with support from ALEM, is expected to remain the investor, using Smart EPC contract templates for procurement.

Rivas:

- The municipality had already installed LED lighting, so the pilot focused on smart integration using the UVAX system.
- Implementation was conducted in-house, without a formal tender or third-party investment.

Poland:

Warsaw:

- the LUG company is indicated as a potential contractor, no EPC contract was concluded.
- The city shifted from the EPC approach to a direct investment model, funded from own resources with elements of Smart City solutions.

Krakow:

- Initially intended as an EPC, it shifted to a delivery and installation model financed through the National Recovery and Resilience Plan (RRF) with elements of Smart City solutions.
- The city is expected to remain the investor.

France:

Evian-les-Bains:

This is the only French pilot that followed a Smart EPC model. However, CITEOS, the selected contractor, did not act as an investor in the full ESCO sense. Under French law, third-party financing of public lighting through EPCs is not permitted. Instead:

- The municipality remained the primary investor.
- Funding was provided via public procurement, with support from the departemental energy syndicate Syane and AURA-EE.
- CITEOS assumed responsibility for achieving performance results but not for financing the initial investment.

Other French municipalities (La Roche-sur-Foron, Samoens, Bluffy):

- These pilots did not use EPC contracts, but involved smart technologies.
- Investment came directly from municipal budgets, with technical assistance from Syane.
- Contractors such as SPIE, PORCHERON, BEEZEELINX and LACROIX were hired through standard public tenders for upgrades or smart technology deployment, not through ESCO models.

Croatia:

Karlovac:

- The only case where a full EPC model with ESCO involvement was implemented.
- Verso Altima signed an EPC contract and took on both performance and financing responsibility, thereby acting as the ESCO and investor.
- This model included full risk transfer and payback through energy savings.

The financing models across Smart EPC pilots demonstrate a wide spectrum, from full EPCs with ESCO-led implementation to direct public procurement and regional collaboration models.

EPC-based financing (Karlovac and partially Evian-les-Bains)

Karlovac:

- Followed the classical EPC model, with ESCO financing and payback through guaranteed savings.
- Full contract risk, performance guarantees and conditional acceptance procedures were included.

Evian-les-Bains:

- Although using an EPC-style contract with CITEOS, the municipality itself was the investor.
- The key feature was a performance-based structure and hypervision platform for management, not third-party financing.

Public financing with performance focus in Warsaw and Krakow:

- Both initially planned EPCs but shifted to publicly financed models, due to:
  - Regulatory barriers (e.g., heritage approvals in Warsaw),
  - Availability of favorable public loan instruments under the RRF.
- Smart City features (e.g., PIR sensors, EV chargers) are planned, but paid for by the city and contractors selected via public tenders.

Grant-supported local procurement in France (municipalities):

- Implementations were funded by municipalities, with support from Syane, which centralizes resources and negotiates grant support.
- Syane also deployed a hypervision platform shared by multiple municipalities — improving scale and reducing costs.

In-house implementation in Rivas (Spain):

- No financing structure was needed. The municipality managed the upgrades internally.
- Focus was on connecting existing LED infrastructure to smart platforms (e.g., sensors, environmental monitoring, occupancy-based lighting).

6. Key lessons learnt from the Smart EPC pilot projects

The Smart EPC pilot projects, implemented across Croatia, France, Poland and Spain, provide a comprehensive set of lessons and best practices for modernizing public lighting system through innovative, flexible and sustainable approaches. The following are the most significant findings:

Flexibility and local adaptation are essential
Each city or municipality faced unique challenges; ranging from heritage constraints in Warsaw, financing shifts in Krakow, to technical feasibility in Murcia. The Smart EPC model's flexibility enabled cities and municipalities to adapt their projects to local regulatory, financial and infrastructural realities, proving that a one-size-fits-all approach is rarely effective.

Standardization enables future scalability
Cities like Krakow and Karlovac adopted interoperability standards, ensuring that smart lighting solutions can integrate across different suppliers and technologies. This standardization is crucial for future expansion and multi-vendor compatibility.

Careful financial planning is critical
The choice of financing models significantly impacted project timelines and scope. For example, Warsaw and Krakow had to revise their initial EPC plans due to new funding opportunities and administrative changes, while Evian-les-Bains in France successfully leveraged full EPC financing with guaranteed energy savings. Early clarification of financial models is a key to smooth implementation.

Phased and modular implementation works best
Many pilots, such as Karlovac, demonstrated that starting with LED replacements and preparing for future smart integration allows for modernization even with limited budgets. This modular approach reduces risk and allows for gradual adoption of advanced features.

Intelligent control and monitoring deliver substantial benefits
The integration of smart control and monitoring systems (e.g., Rivas' UVAX platform) can yield significant energy and operational savings, even without full infrastructure replacement. Real-time data and adaptive lighting controls improve efficiency and maintenance.

Smart lighting as a platform for broader urban services
Several pilots (e.g., in France and Spain) leveraged public lighting infrastructure to support additional Smart City services, such as EV charging, air quality monitoring, WiFi and surveillance. However, the feasibility of these services depends on careful evaluation of power capacity and cost-benefit analysis.

Regional and departmental collaboration amplifies impact
Collaboration with regional bodies (e.g., Syane in France) allowed multiple municipalities to share resources, expertise and infrastructure, reducing costs and accelerating smart lighting rollouts. Departmental support proved especially crucial for smaller municipalities.

Heritage conservation and modernization can coexist
Projects in cities or municipalities with historic areas (e.g., Warsaw, Krakow and French municipalities) showed that smart lighting upgrades can be implemented without compromising heritage values, by adapting fixture designs and using appropriate light temperatures.

Stakeholder engagement improves outcomes
Early and ongoing engagement with stakeholders, including residents, technical experts and heritage authorities, helped align project goals, resolve conflicts and foster community ownership, as seen in Krakow and Warsaw.

Centralized management and hypervision platforms increase efficiency
The deployment of centralized platforms (e.g., hypervision in Evian-les-Bains and other Syane's municipalities) enabled real-time monitoring and control of lighting systems across multiple sites, improving operational efficiency and supporting large-scale energy savings.

Administrative and regulatory challenges require adaptive strategies
Changes in local leadership, regulatory requirements and funding instruments (e.g., Poland's shift to Recovery and Resilience Facility funding) necessitated adaptive planning and sometimes led to delays or scope adjustments.

Technical documentation and procurement processes must be robust
Comprehensive audits, clear technical specifications and transparent tendering processes were essential for project success, as demonstrated in Karlovac and Murcia.

Smart City integration should be prioritized based on feasibility
Not all Smart City services are immediately viable; pilots in Murcia and Rivas found that infrastructure limitations and power requirements must be thoroughly evaluated before integrating new services like EV charging or 5G.

Smart EPC provides a replicable model for sustainable urban lighting
Despite diverse approaches, all pilots confirmed that the Smart EPC framework offers a flexible, scalable and technically sound basis for modernizing urban lighting and supporting broader Smart City objectives.

These key lessons learnt collectively demonstrate that Smart EPC can drive significant energy savings, operational improvements and urban innovation, provided that projects are tailored to local contexts, supported by robust planning and implemented with a phased, collaborative and stakeholder-driven approach. The pilots offer a blueprint for future sustainable urban infrastructure modernization across Europe.

7. Smart EPC standardized documentation adaptation for follow-up cities and municipalities

To adapt the standardised Smart EPC documentation to better suit different countries' needs, the project partners developed and piloted a flexible framework, then implemented national adaptations based on regulatory, technical and market realities. The following key strategies and recommendations emerge from the project's adaptation process and are supported by detailed comparisons and feedback from relevant stakeholders:

Embed national legal and regulatory requirements

- Integrate country-specific procurement laws, contract structures and public sector requirements directly into the administrative and legal sections of the documentation. For example, France uses CREM contracts for public lighting EPCs, while Croatia's EPCs must align with the Energy Efficiency Act and specific public procurement rules.
- Include references to national standards and technical regulations (e.g., lighting norms, environmental rules, safety codes) as annexes or appendices, allowing easy updates if regulations change.

Allow modular and flexible documentation structure

- Separate administrative and technical documents: Some countries (France, Spain) prefer two distinct documents; one for administrative/contractual terms and another for technical specifications, making it easier to adapt and update only the relevant sections for future projects.
- Use modular contract sections: Adapt the documentation to allow optional modules (e.g., for smart services like EV charging, WiFi, sensors) that can be included or excluded based on local priorities and market maturity.

Adjust technical specifications to local context

- Set minimum technical requirements but allow bidders to propose solutions: The documentation should specify output-based requirements (e.g., minimum energy savings, lighting quality, system interoperability) but leave room for contractors to propose how these are achieved, as technical solutions and available products vary by country and market.
- Accommodate local infrastructure and climate: For example, solar LED lighting is more viable in sunny regions like Murcia, Spain, while other areas may prioritize grid-connected solutions.

Reflect national financing and risk practices

- Adapt financing and risk-sharing clauses: In some countries, third-party financing or leasing is not permitted (e.g., France), while in others, ESCOs may bear more or less risk. The documentation should clarify which party is responsible for financing, performance guarantees and revenue sharing, based on national practice.
- Include country-specific performance measurement and verification protocols: For example, some countries require IPMVP Option A (based on power), while others may have different standards for energy savings verification.

Incorporate local stakeholder feedback and market conditions

- Consult with local authorities, ESCOs and technical experts during adaptation to ensure the documentation addresses real market needs and administrative capacity. For example, the French adaptation involved energy syndicate, while in Croatia and Spain, city or municipality technical departments and energy agencies played key roles.
- Adjust documentation to reflect the maturity of local smart services markets: Where markets for non-energy services (e.g., e-mobility, sensors) are immature, include these as optional or pilot features rather than mandatory requirements.

Streamline and simplify where possible

- Reduce administrative burden: Feedback from Spain highlighted the need to minimize bureaucracy and streamline documentation to avoid excessive delays, especially for smaller municipalities.
- Provide clear templates and checklists: Standardise core sections, but offer guidance on which sections must be adapted and how, to help local teams efficiently tailor the documents.

Enable future updates and local innovations

- Design documentation to be easily updatable: As new technologies, regulations, or market opportunities emerge, the documentation should allow for quick revision of technical annexes or contract modules.
- Encourage inclusion of local innovations: Allow cities and municipalities to add requirements for new Smart City features or environmental/social objectives as their needs evolve.

Examples from the pilots

- **France:** Adapted documentation to match the CREM contract model, split administrative and technical parts and excluded third-party financing clauses not permitted nationally. Penalties and performance monitoring were also tailored to local practice.
- **Spain:** Added national legislation references, separated documents, and included solar LED as a viable option for certain regions. Administrative and technical requirements were simplified to reduce complexity.
- **Croatia:** Used the standard documentation with minimal changes, but included all national legal references and adapted clauses for EV charging services to reflect local market immaturity.
- **Poland:** Compared Smart EPC templates to national guidelines, added compliance with new energy efficiency regulations and adjusted risk allocation and verification procedures to align with Polish practice.

8. Learn from our project - Smart EPC facilitation service

The Business Model Canvas method

The Smart EPC facilitation service provides support to cities in preparation and execution of the Smart EPC concept. This standardised consultation service aims to improve the knowledge and skills of both public authorities and private sector in integrating standardised Smart EPC concept and documentation for financing energy efficiency projects in the public lighting sector, not only in pilots but also in the wider European market.

By providing a comprehensive approach to energy savings, the Smart EPC facilitation service helps cities and organisations improve their consumption profile by implementing energy efficiency as well as Smart City components. It guides them on the technical, financial, and legal aspects of energy performance contracting and enable them to achieve their energy efficiency targets. The service also facilitates the development of innovative financing solutions to support the implementation of Smart EPC projects.

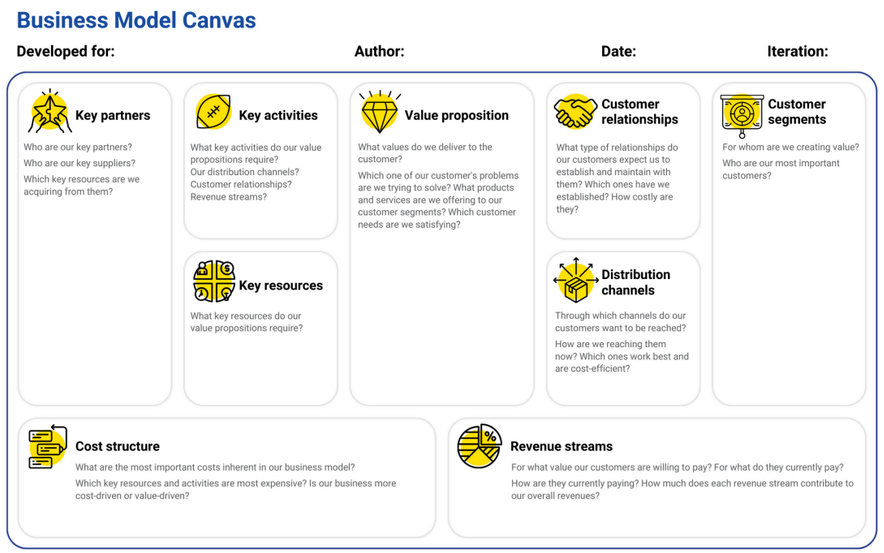


Figure 22
Business Model Canvas for the Smart EPC facilitation service

The Business Model Canvas method applied for the business model development (Figure 22) provides a structured and visual approach to designing, analysing and refining our business model. The canvas enables us to identify key components, such as customer segments, value propositions, key activities, partnerships, revenue streams and cost structure, allowing for an agile and adaptable business strategy.

Key activities

Smart EPC team of experts will focus on facilitating the development of the entire project lifecycle, from conception to completion. These services include:

- Project design and assessment: supporting stakeholders to identify the most suitable Smart EPC projects for their specific needs and energy goals. Involves evaluating existing energy infrastructure, understanding consumption patterns and recommending tailored solutions;
- Financing strategies: assistance in exploring various financing options to fund their Smart EPC projects. Involves analysing available financial resources, exploring partnerships with financial institutions and seeking potential grant opportunities;
- Validation of the design and implementation of the Energy Efficiency measures: The Smart EPC facilitation service helps identify and implement a diverse range of energy and non-energy-related measures in public lighting. Involves integrating Smart City applications with energy efficiency initiatives to maximise the overall impact;
- Guidance and training: With a commitment to knowledge transfer and capacity building, throughout the identified timeline, the team provides guidance and training sessions to cities, ESCOs, contractors, etc. The training encompasses the best practices for preparing and executing successful EPC projects, promoting a sustainable approach to energy management;
- Market Research and Analysis: Constant market research and analysis is undertaken to stay updated on the latest trends, opportunities, and challenges in the energy efficiency and Smart Cities sector;
- Concrete examples from Smart EPC pilots: Pilots' progress allows for the constant improvement of the training content and the facilitation service as a whole;
- Continued training post-project: As part of the commitment to long-term sustainability, the service is available even after the Smart EPC project comes to an end. This post-project action enables clients to maintain and optimise the energy efficiency measures they have implemented.

Value proposition

The Smart EPC facilitation service offers multiple value propositions that cater to the needs of its diverse customer segments. It supports the customer throughout its entire smart EPC journey, removing technical, administrative, and financial hurdles while ensuring a cost-effective solution that brings long-term energy and cost savings.

The primary values offered include:

- Expertise and Consultation: service provides support and guidance throughout the entire project lifecycle, from conception to completion. Expertise includes project design and assessment, financing strategies, energy efficiency measures, and training;
- Tailored Solutions: service provides tailored solutions based on clients' specific needs and energy goals. This involves evaluating existing energy infrastructure, understanding consumption patterns, and recommending appropriate strategies;
- Innovative Financing Solutions: service facilitates the development of innovative financing solutions to support the implementation of Smart EPC projects. This involves exploring partnerships with financial institutions and seeking potential grant opportunities;
- Training and Capacity Building: service enables knowledge transfer and capacity building by providing guidance and training sessions to clients, with focus on the best practices for preparing and executing successful EPC projects;
- Resilience and Adaptability: service also supports cities and organisations in enhancing their resilience and adaptability to changing environmental and economic scenarios through energy-efficient measures and Smart City applications.

Key partners

The Smart EPC facilitation service has multiple key partners that support its operations:

- Financial Institutions: These partners provide the necessary financial resources and innovative financing solutions for Smart EPC projects;
- ESCOs (Energy Service Companies): These technical partners implement the energy-saving measures and assume the risk associated with the projects;
- Public Authorities: These partners provide access to public infrastructure and utilities, data on energy consumption at the municipal level, throughout the Smart EPC projects' implementation;
- Facilitators (Energy Agencies and Consultants): Facilitators provide critical advice and support to the team of experts within the facilitation service and will be responsible for the capacity-building programme.

Revenue streams

The Smart EPC facilitation service will be organised as a business, and several business models can be considered. Types of financing of Smart EPC facilitation services (sustainability of an action):

Fee-for-service business model

One possible business model is a fee-for-service model, where the Smart EPC facilitation service charges a fee for its services. The fee-for-service model can be based on a percentage of the total cost of the Smart EPC project or a fixed fee. The fee-for-service model ensures that the Smart EPC facilitation service is financially sustainable and can cover its costs.

Performance-based business model

Another possible business model is a performance-based model, where the Smart EPC facilitation service is paid based on the performance of the Smart EPC project. This model can be based on the Smart EPC concept's energy savings and additional renumeration. The performance-based model aligns the interests of the Smart EPC facilitation service and the project representatives (local authorities/owners of public lighting infrastructure), ensuring that the Smart EPC facilitation service is incentivised to deliver high-quality services.

Partnering with financial institutions

The Smart EPC facilitation service can also consider partnering with financial institutions to provide innovative financing solutions for Smart EPC projects. The partnership model can be structured in several ways, such as revenue sharing or joint ventures. The partnership model ensures that the Smart EPC facilitation service can access funding for Smart EPC projects and can offer attractive financing solutions to project representatives.

EU funding as a source

EU funding can be one possible funding source enabling a financially sustainable and wider range of clients (other energy agencies, ESCOs, or others). For example, the Smart EPC facilitation service could be funded under the LIFE CET PDA for a specific public authority.

8.1 Smart EPC training materials

Smart EPC presentation slides & learning video

The Smart EPC project is focused on revolutionizing traditional Energy Performance Contracts (EPCs), particularly within the domain of public lighting projects. By integrating additional energy and non-energy-related services into EPCs, the smart services, such as Smart City applications. The training materials are designed to introduce cities and facilitators to the deliverables and tools developed under the Smart EPC project, guiding them on how to utilize these resources to develop and implement pilot Smart EPC projects within their own communities.

Expected outcomes for cities:
Gain a comprehensive understanding of the SMART EPC project and the tools available to enhance streetlighting and other public services through innovative EPC models. Get equipped with the tools and standardized EPC contract and tender documentation to:

- Evaluate the readiness level of your public lighting to undergo smart EPC modernization;
- Make your project more attractive and financially viable by integrating energy and non-energy services (for example Smart City components, air quality sensors, traffic management, extended Wi-Fi and next generation cellular communications like 5G or electric vehicle charging stations) into one tender process;
- Attract ESCO companies to tender for small-scale projects since the standardised documents help them execute due diligence and make offers in a relatively short time period;
- Explore the effectiveness of additional investments in EPC projects non-related to public lighting;
- Get inspired by the case studies of cities that have already used our smart EPC concept (for example, the city of Karlovac in Croatia).

Expected outcomes for facilitators:
Acquire the knowledge and tools necessary to support cities in the successful implementation of SMART EPC projects, thereby contributing to the broader adoption of enhanced energy performance contracts
:gain in-depth knowledge of the SMART EPC tools and methodologies that will empower you to assist cities in the preparation and implementation of their EPC projects. You will be well equipped to:

- Assess the readiness of cities' public lighting systems for SMART EPC modernization.
- Support cities in making their projects more attractive and financially viable by incorporating both energy and non-energy services, such as Smart City components, air quality sensors, traffic management, extended Wi-Fi, next-generation cellular communications (like 5G), and electric vehicle charging stations, into a unified tender process.
- Guide ESCO companies in tendering for small-scale projects using standardized documentation, helping them conduct due diligence and submit offers efficiently.
- Evaluate opportunities for additional investments within EPC projects, even those not directly related to public lighting.

Recent webinars key takeways

- EPC represents a shift from traditional investment models where public authorities bear the majority of project risks to a model where ESCOs take on these risks, thus making projects more sustainable.
- The traditional procurement methods are often seen as simpler due to familiarity, yet they expose authorities to hidden risks and costs that can be alleviated through alternative models like EPC.
- Traditional EPC models require multiple contracts, leading to a fragmented management process. Smart EPC simplifies this by providing a single contract which clearly defines the roles, responsibilities, and risks associated with a project.
  By integrating energy-efficient technologies, municipalities can achieve operational savings without incurring additional debt, enabling funds to be redirected to other public service enhancements.
  The integration of non-energy services (e.g., smart sensors and public facilities) within the EPC framework enhances project attractiveness and financial viability, showcasing a holistic approach beyond energy efficiency alone.
- Utilizing standardized documents and templates simplifies the procurement process, reduces administrative burdens, and encourages broader participation among local authorities and ESCO companies.
- Engaging decision-makers early in the project lifecycle, as reinforced in the action plan template, is crucial for garnering the necessary political will, which can safeguard the project's longevity.
- The flexibility in the Smart EPC contract allows cities and municipalities to adapt terms to meet specific local regulatory environments and project requirements. This adaptability can foster innovative solutions tailored to local needs, encouraging greater participation and interest in adopting Smart EPC models
- Establishing key performance indicators (KPIs) is crucial for transparency and accountability in EPC contracts. Monitoring these KPIs ensures that both parties adhere to contractual obligations and facilitates clear communication regarding project performance.
- Identifying and assigning clear risks helps prevent undue burdens shifting back to the public sector. This risk management framework is critical to the financial feasibility of smart infrastructure projects, ensuring that public funds are safeguarded while encouraging private sector investment.
- While the focus is on public lighting, the principles discussed can be applied to a variety of public infrastructure projects. This opens avenues for municipalities to explore EPCs for additional services such as electric vehicle charging infrastructure while ensuring they remain commercially viable.

Conclusion

The Smart EPC project demonstrates that the modernization of public lighting systems can serve as a powerful catalyst for the transformation of cities into smarter, more sustainable urban environments. By developing and piloting standardized Energy Performance Contracting (EPC) documentation that integrates both energy and non-energy services-such as EV charging, advanced communication technologies and Smart City infrastructure, the project has provided a robust, replicable framework for local authorities across Europe.

Through pilot implementations in diverse regulatory and market contexts, the project has validated the adaptability and practical benefits of the Smart EPC approach. The integration of energy efficiency measures with Smart City services not only delivers significant operational and environmental benefits, but also opens new avenues for public service improvement and revenue generation. The standardized documentation, analytic tools and capacity-building materials produced by the project have proven effective in reducing administrative burdens, increasing market participation and ensuring high-quality, future-ready solutions.

The following Smart EPC project key findings could be extracted:

- The project demonstrates how public lighting infrastructure can be upgraded not only for energy savings but also to serve as a platform for a wide range of smart city applications, including traffic management, environmental monitoring, and public safety.
- A principal output is the development of standardized EPC documentation that enables pay-for-performance schemes, real-time monitoring, and the bundling of energy and non-energy services. This documentation is designed to be adaptable across diverse national regulatory and market contexts.
- The Smart EPC concept and documentation were tested through pilot projects in Croatia, France, Poland and Spain, each with unique regulatory, technical, and market conditions. These pilots validate the adaptability and scalability of the Smart EPC framework and provide replicable models for other cities and municipalities.
- The project delivers training and facilitation services to local authorities and consultants, strengthening their ability to prepare, procure, and manage Smart EPC projects.

Key lessons from the project highlight the importance of flexible contract structures, clear risk allocation and the inclusion of both commercial and non-commercial services to maximize project viability and attractiveness. The Smart EPC methodology empowers cities and municipalities to tailor solutions to their specific needs while maintaining a unified standard that facilitates replication and upscaling.

As cities and municipalities continue to face challenges related to energy efficiency, climate goals and digital transformation, the Smart EPC framework stands out as a practical, scalable and innovative tool. It not only supports the immediate goals of energy savings and operational efficiency but also lays the groundwork for broader Smart City development, improved quality of life and long-term sustainability. The project's outcomes and resources provide a strong foundation for continued progress in the modernization of public infrastructure across Europe and beyond.