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Priority Axis 1. Promoting Mediterranean innovation capacities to develop smart and sustainable growth

Specific Objective 1.1 To increase transnational activity of innovative clusters and networks of key sectors of the MED area

WP3 – Testing

Activity 3.2 – Testing preparatory activities

Deliverable 3.2.3 – Pilot Deployment Operational Plan Framework

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1 Contents

2 Introduction

Deliverable 3.2.3 is about setting the necessary Operational Plan Framework for the planned pilot deployments. The deliverable describes the different deployment use cases of the transnational pilot testing and presents the Functionalities and the deployment specific applied measures for each involved project partner. Together with previous deliverables D3.2.2 and D3.2.3, the present deliverable is important for the replicability and scalability of the project in other sites in the MED area and beyond.

As stated in previous deliverables pilot testing focuses on two different themes: energy efficient buildings and smart public lighting. Pilot deployments with reference to energy efficient buildings include the following regions and localities: Western Greece (EL) – {Patras, Messolonghi, Pyrgos}, Lisbon (PT) – {Palmela, Setubal, Sesimbra}, Lombardy (IT) – {Milan}. On the other hand, pilot deployments with reference to smart public lighting include the following regions and localities: Abruzzo (IT) – {Pescara}, Auvergne-Rhône-Alpes (FR) – {Lyon}, Andalusia (ES) – {Huetor Tajar}, Bosnia and Herzegovina – {East Ilidza}. The following chapters describe the pilot deployment operational plan for each of the involved regions and localities.

The pilot deployment use cases for each region are shown in Table 1.

Country	Region	Locality	Theme	
			Building Energy Efficiency	Smart Public Lighting
BiH	BiH	East Ilidza		X
EL	Western Greece	RWG	X	
		Patras	X	
ES	Andalusia	Huetor Tajar		X
FR	Auvergne-Rhône-Alpes	Lyon		X
IT	Abruzzo	Pescara		X
	Lombardy	Milan city	X	
		Milan PoliMi	X	
PT	Lisbon	ENA	X	

Table 1 Pilot deployment use cases

3 Pilot Deployment in East Ilidza, BiH

The pilot deployment use case in the area of East Ilidza, in Bosnia and Herzegovina deals with smart public lighting. East Ilidza lies in East Sarajevo City, with 14.763 permanent residents and a population density of 530 inhabitants/km2 in a total area of 27.9 km2 which is mostly suburban and rural area. Part of the area is undergoing a constant process of urbanization, which leads to a need for specific public services as a public lighting system. Unfortunately, the vast majority of existing public lighting systems are based on obsolete and inefficient technologies, leading to increased energy consumption. This consumption can be increased through the use of new communication and control technologies.

The City authorities aim to transition from a conventional to a smart public lighting system that will reduce energy consumption and simplify system maintenance, while at the same time providing an appropriate level of lighting that will maintain high levels of public safety. Implementation of the LED-based public lighting system, which is energy-efficient and environment-friendly with additional smart functionalities as dimmable and manageable lights depending on the part of the day and year, real sunlight cycle, traffic and other factors, is critical for energy and costs savings for the city.

3.1 Summary of the pilot deployment

The pilot will be deployed in the Municipality of East Ilidza, in a town square called Veljine. The existing lighting system in the area consists of 36 street lamps that cover a length of 272m. The deployed pilot system will include 20 Energy Meters installed on street light poles, coupled with Energy Metering Controllers and Sensors that will monitor air quality, motion and ambient light conditions. The system will also monitor several public lighting parameters and statistics that will be used for future profiling.

System network communication will be done using LoRaWAN radio communications technology in combination with Wi-Fi where necessary. Interconnection between the sensor network and the Data Center will be performed over the mobile network. Details of the communication system are given in following chapters.

For the needs of the pilot deployment a standalone server will be deployed by the City, rather than a Data Center. All aspects of the system will be expandable and scalable both in software and hardware, so that in the future it can be converted into an integrated control system for Smart City of East Sarajevo and all other services within the jurisdiction of the City.

3.2 User requirements

The main goal of the pilot deployed by RAIS is to create an experimental framework that will allow users to test some smart city applications in the real-time and real environment under different parameter settings and environmental factors. To achieve this, the service should meet the following User Requirements that have been laid out in Deliverable 3.2.1:

- Sensors (Sensor Network): Internet of Things infrastructure, comprising various sensors and embedded infrastructure will be used to make the system more robust and provide various kinds of information. For this pilot project, deployed sensor network should support primary monitoring and management of the public lighting system, as well as statistical analysis for future lighting profiling, and secondary to provide additional co-located applications as Air Quality, Motion and Ambient Lighting monitoring, which are perfectly matched for co-location and installation at the once. Motion and Ambient Lighting monitoring will be utilised for energy saving applications.
- Data Collection Point: The City has a plan to develop the Data Center as a central point of the data collection, storage and data analytics. This center is going to be enhanced by Machine Learning, Data Mining and Artificial Intelligence algorithms to be able to reach a deeper knowledge. In this pilot project, as an early-stage of developing smart city ecosystem, the focus will be on data logging and user-friendly presentation. With the future growth of the sensor network and with the implementation of new smart applications with different sensors, the data collection is going to reach higher volume, relevance and diversity which enables deep knowledge collection and makes sense to implement full data center. The system is designed with the following goals:
    - Gather the public lighting system parameters values as a key data for monitoring and management of the system;
    - Gather the environmental data from the predefined locations of the interest (Air Quality, Noise and Light pollution, statistic focused on the behavior of the citizens as a counter of people passing the locations in the real-time, e.g, what is useful for the future profiling and planning)
- Open Data Policy: The City has a plan to support the start-up community and make many of collected data public. Wider availability of the collected data is a key enabler to motivate the local engineering community to develop a different type of software applications based on them.
- Wireless networking will be deployed for interconnecting the different components of the system as described in the previous and following sections.

3.3 Functionalities

The system has the following functionalities:

- Possibility of intelligent street lighting management, as soon as significant energy savings are achieved
- Remote control of each individual street lamp, which can work in multiple modes: ON, OFF, Dimmed (adaptable, 10% -100%)
- Working according to predefined rules, so that certain parts of the day apply a different predefined mode of operation (all bulbs are turned on at 19:00 and turn off at 7:00, e.g.)
- The ability to manage street lighting based on sensor signals installed on the pillar of street lighting and whose role is the detection of the level of illumination and motion detection. The possible scenario is as follows: All the bulbs go off when no motion is detected. Movement sensors are placed on each pillar of street lighting and detect movements on the surface beneath the pillar. After the movement is detected, only certain bulbs are turned on, while the others work in a different mode of operation (either is turned off or dimmed at 10-30%).
- Gateway collects data from the end devices (sensors, controllers) via the LoRaWAN network and forwards them further via Ethernet, mobile GPRS or any other telecommunication (wire or wireless) connection to the network server.
- The network server processes all incoming data eliminates duplicate packets, adjusts data transfer rates and sends certain data packets to the application server.
- Based on the received data, the real-time image of the complete system is generated through the software application and based on these data can perform certain actions through the user interface of the application installed on the application server.
- The system also supports the mode of operation in fully automatic mode.

The benefits of the system are as follows:

- Provides full control over the street lighting system
- Enables significant energy savings
- Fully scalable

- Supports the use of equipment of different manufacturers that are compatible with the data transfer standard used
- Enables full control of each individual module of the system
- Extensible with additional sensors and management network
- Most software solutions are not limited to the number of sensors
- Data uses standard protocol but also can be connected to any telecommunication network
- The LoRaWAN network has a very large bandwidth and availability, low power consumption, good indoor coverage and a good data protection mechanism.

3.4 Devices and sensors

LoRaWAN network architecture is deployed in a star-of-stars topology in which gateways relay messages between end-devices and a central network server. The gateways are connected to the network server via standard IP connections and act as a transparent bridge, simply converting RF packets to IP packets and vice versa [57].

The system consists of end device (sensors, controllers), network (LoRaWAN connection for communication between sensors/controllers and gateway and IP connections for communication between the gateway and network server), gateway and a network server.

The main advantage of the LoRa network is that it allows the connection of an unlimited number of end devices, has a wide range of coverage with minimal power consumption.

In addition to covering large surfaces and having low power consumption, LoRa has deep coverage within buildings and a good data protection mechanism.

Some of the other advantages of LoRaWAN [58]:

- It uses 868 MHz/ 915 MHz ISM bands which is available worldwide,
- It has very wide coverage range about 5 km in urban areas and 15 km in suburban areas,
- Single LoRa Gateway device is designed to take care of 1000s of end devices or nodes,
- It is widely used for M2M/IoT applications,
- LoRaWAN supports three different types of devices viz. class-A, class-B and class-C.

One of the disadvantages is that the LoRaWAN network size is limited by a parameter called a work cycle. It is defined as the percentage of time the channel can occupy. This parameter derives from regulation as a key limiting factor for traffic that serves the LoRaWAN network.

Basic features of LoRa are displayed in the Table 2 [59]:

Feature	LoRaWAN	Narrow-Band	LTE Cat-1	LTE Cat-M	NB-LTE
Modulation	SS Chirp	UNB/GSK/BPSK	OFDMA	OFDMA	OFDMA
Rx Bandwidth	500-125 KHz	100 Hz	20 MHz	20-1.4 MHz	200 KHz
Data Rate	290 bps-50 Kbps	100 bit/s 12/8 bytes max	10 Mbps	200 Kbps-1 Mbps	20 Kbps
Max Output power	20 dBm	20 dBm	23-46 dBm	23/30 dBm	20 dBm
Battery life time	105 months (≈ 9 yrs)	90 months (7.5 yrs)		18 months (1.5 yrs)	
Link budget	154 dB	151 dB	130 dB+	146 dB	150 dB
Security	Yes	No	Yes	Yes	Yes

Table 2. LoRaWAN, Basic Features

3.4.1 Compatible System Components

3.4.1.1 LoRaWAN compatible controllers (10 pieces)

It is necessary to install the controller on each streetlight lamp (up to 400W) to allow for individual remote control. The controller's role is to carry out turn on, turn off and operations for dimming light. Depending on the different project tasks, three classes of devices can be used: classes A, B, and C. LoRaWAN networks allow two-way communication between the endpoints and the server, while the mutual communication between the end devices is not enabled.

These devices can have autonomy in operation, working through pre-defined rules (timing of ignition and extinguishing), or based on signals received through a digital input from, for example motion sensor.

These devices have integrated light level sensor. For data transfer use minimal bandwidth and support advanced data synchronization and notification mechanism.

3.4.1.2 LoRaWAN compatible motion sensor (10 pieces)

Sensors will be installed on each pillar of street lighting. The main role of the motion sensor is to detect movement and send a signal that it is necessary to turn on / off the bulb. The idea is that the bulb under which the detected object is operating in 100% mode, while the other bulbs work in the mode of 10 or 30%. It can also be set to ensure that all street lamps are bright in automatic mode of 10% at a certain time of night, when the assumption is that there will be neither passers nor vehicles to fall after the motion sensor notices movement.

3.4.1.3 LoRaWAN compatible gateway (1 piece)

One area where LoRaWAN differs from other network specs is that it uses a star architecture, with a central node to which all other nodes (end device) are connected and gateways serve as the transparent bridge relaying messages between end-devices and a central network server in the backend. Gateways are usually connected to the network server via standard IP connections while end-devices use single-hop wireless communication to one or many gateways. All end-point communication is bi-directional, and supports multicast, enabling software upgrades over the air [60].

During the implementation, a gateway of different manufacturers that are compatible with LoRaWAN can be used.

3.5 Data storage and analysis

The LoRaWAN network server manages the network. The networks server has all the intelligence. It filters the duplicate packets from different gateways, does a security check, sends ACKs to the gateways. In the end, if a packet is intended for an application server, the network server sends the packet to the specific application server [61].

The computer is used to control the end devices via the control software. End-of-device data can be collected on the computer, and based on these data, define the actions required.

Server or cloud-based, with an advanced user management system, control software is designed to efficiently manage street lighting projects regardless of their size, up to a virtually unlimited number of lamp controllers in large urban agglomerations and even a geographically unconnected metropolis. The software application can manage different communication technologies (LoRa, PLC, GSM/GPRS), being able to integrate street lighting control hardware solutions from different suppliers [62].

One of the most important features the software needs to fulfill is to be user-friendly and scalable in the way that street lighting management platform can subsequently be adapted to become smart city management platform.

4 Pilot Deployment in Region of Western Greece

Region of Western Greece (RWG) is a public authority, which acts as the Local representation of Central Government in Western Greece. It consists of three Regional Units, namely the Former Prefectures of Aitoloakarnania, Achaia and Ileia, which span an area of 11.350 square kilometres (8,6% of Greece total surface), with a population of 680.190 inhabitants (2011). The top strategic priority of RWG is the development of an Energy Planning through the organization of Energy Communities and the construction of an Energy Observatory for public buildings in Western Greece, of which this pilot project is the first step.

4.1 Summary of the pilot deployment

Pilot deployment in RWG involves installing Smart Energy Metering Controllers in public buildings. The selected buildings are:

- The RWG Public Building in Messolonghi - capital town of Aitoloakarnania prefecture
- The RWG Public Building in Pyrgos – the capital town of Ileia prefecture
- 15 rented buildings throughout the region
- the Pilot School of the University of Patras located in the area of Rio, Patras

The pilot aims to improve Energy Efficiency in public buildings through the usage of high-performance and affordable IOT technology that monitors electrical energy consumption in buildings in real time. This monitoring is done using Smart Energy Meters installed in the buildings. More specifically in each of the first two buildings a Smart Energy Meter will be installed in the main electrical panel together with 4 more Energy Meters for each use specific electrical line (lighting, HVAC etc.). For the 15 rented buildings, an Energy meter per building will be installed while for the school the pilot will deploy one Energy Meter for each of the three buildings of the school.

4.2 User requirements

Tackling each User Requirement introduced in Deliverable D3.2.1, the general description of the proposed solution is given together with the reasons behind the adoption of this particular strategy:

- Gather information about electric energy consumption: Smart Electrical Energy Meters will be used, because of their simplicity of deployment and the potentiality behind this measurement to infer on the building overall consumption causes.
- Store Data collected: wireless technology – together with some obvious wired components – and a central server are sufficient to memorize the measurements in order to make them available for a following analysis.
- Stored data access: the data storage will be designed so to make the data easily accessible through internet connection and easy to analyze.
- The pilot will utilize innovative IoT technologies and open source solutions where applicable.
- The solution must be scalable and replicable in other similar cases.

4.3 Functionalities

The functions introduced by this pilot deployment are mainly focused around the direct fulfillment of the presented user requirements. The functionality can be presented in the following list:

- Providing a Smart Electrical Energy Meter which collects consumption data on an initial premise basis of 15 minutes. Each building will be provided with its meter in order to improve the following consumption studies.
- Installing a data storage system to collect all the measured data coming from the previously introduced meters
- Data accessibility will be granted by a correct connection set-up of the data storage system

4.4 Devices and sensors

As mentioned in the description of the pilot deployment, 28 Smart Electrical Energy Meters will be used to cover all the buildings under this study case.

4.5 Data storage and analysis

Data from all smart energy meters will be collected on a per premise basis every 15 minutes. Using wired and wireless technology all data will be delivered to the main server, which will be installed in Patras, through the National Public Administration Network –Syzefxis.

5 Pilot Deployment in Industrial Systems Institute's premises in Patras, Western Greece

The Industrial Systems Institute (ISI) is situated in the building of the Patras Science Park (PSP), Platani, Patras, Greece. It uses 5 office spaces of about 300 sq.m. from the entire building complex of the Park. The power consumption comes from electrical equipment that mainly comprises of computers and servers as well as lighting of the office spaces. All ISI offices are connected via an isolated Ethernet LAN while wireless connectivity is also available in all areas.

5.1 Summary of the pilot deployment

The pilot testing deployment in the premises of ISI addresses two concepts: the concept of energy efficiency and the concept of the building as a living lab. For the first concept energy efficiency scenarios will be executed by monitoring of power consumption and other parameters and analysis of the data to allow for a response to lower power consumption. The second concept involves scenarios in real life use cases in areas where people actually work that will allow experimentation with innovative ideas technologies.

The pilot infrastructure comprises:

- Smart devices, IoT, smart embedded systems
- Wireless connectivity
- Edge computing, Cloud computing
- Big data analytics

This infrastructure will allow for monitoring and analysis of data that will lead to decision making with an eye on lowering energy consumption. To this end, affordable IoT technologies and diverse smart devices together with open source solutions will be used to deliver smart monitoring and control solutions integrating big data analytics for energy consumption and user comfort optimization.

5.2 User requirements

Considering the user requirements presented in Deliverable D3.2.1, different functions must be introduced to meet their fulfillment.

The proposed system should **monitor** and **analyze** in real-time:

- Temperature
- Humidity
- Human Presence
- Light
- Vibrations and sounds
- Door/Window opening

The proposed system should perform **control** and **actuation** with the aims of:

- Energy Consumption optimization
- Maintaining user comfort
- Testing different control and actuation scenarios
- Utilizing edge intelligence

This equipment will be installed in the aforementioned space in order to

- Be possible to derive an energy profile of the offices
- Associate this profile with external climatic conditions
- Perform some data analytics on the collected data that can help derive occupancy behavioral characteristics
- Help in the long-term change occupant behavior towards energy efficiency

5.3 Functionalities

Based on the pilot deployment user requirements, the functionality is presented in the following list:

- **Real Time Monitoring**. The monitoring devices must provide real-time data, meaning that for power consumption at least 0.1Hz sampling rate will be needed (1 sample per 10 seconds). In the case that a measured quantity is characterized by smooth changes, such as temperature, the sampling rate can be decreased to 0.016Hz (1 sample per 1 minute)
- **Real Time Transferring**. The monitored values must be sent from the device to the IoT Platform in a period of no more than 8 sec, 2sec less than the sampling rate. Even if a

gateway is acting in the middle the latency cannot be more than 2 seconds, in order not to have overlapping with the device sampling rate.

- **Real Time Analysis.** The data analysis and decision making that takes place in the platform tier must not in any case be over 10 seconds. Also, any response action such as message sending or enable an actuator to do something must not be over 10 seconds.
- **Real Time Control.** The deployed network system will be able to perform control and actuation on the energy management systems.
- **Diverse device integration.** The system must support a variety of sensing and actuating devices, like smart plugs/sockets, smart switches, power meters, light sensors, temperature sensors, etc. Also, the system must support a variety of different vendors producing the aforementioned devices.
- **Protocols for machine-to-machine (M2M) communication.** Data protocols such as CoAP, MQTT and HTTP/HTTPS must be supported by the infrastructure.
- **Network Protocols.** The devices network must be based on TCP/IP network protocol, or other protocols specialised for M2M communication such Bluetooth, zigBee and Ocean3.
- **Wireless M2M communication.** As the offices are not bigger than 10 meters long, the wireless technologies that can be used must support at least 5 meters to 10 meters physical range. Such technologies can be WiFi, Bluetooth, ZigBee.
- **Data Collection**. All the data will be collected to the Platform Tier. There, the data will be processed (cumulative functions) and the result will be sent to the cloud tier.
- **Big Data Analytics**. Perform of statistical and machine learning analysis in order to detect anomalies or patterns that will provide knowledge for optimizing energy consumption.
- **Infrastructure & Data Visualization**. IoT platform must provide a Graphical User Interface for devices management, data visualization and actuators control. Data visualization include graphic charts and colorful alert messages that can be managed by the user.

5.4 Devices and sensors

The envisaged equipment comprises but is not limited to:

- Energy metering equipment
- Gateways
- Different sensors related to the external climatic conditions and being capable of measuring temperature, humidity, irradiance, light
- Different sensors for determining space occupancy
- Remotely controlled switches

5.5 Data storage and analysis

A digital platform will be utilized for data acquisition from sensing equipment or gateways that will make possible communication with them and data collection. This platform will utilize a fog – cloud structure for data analysis and storage. Fogging will be used to enable management of certain processes at the edge, while other processes will be managed on the cloud. The overall pilot is intended to generate the necessary small-scale investment for pilot testing of different scenarios in a smarter and more energy efficient building context.

The envisaged architecture is depicted in Figure 1.

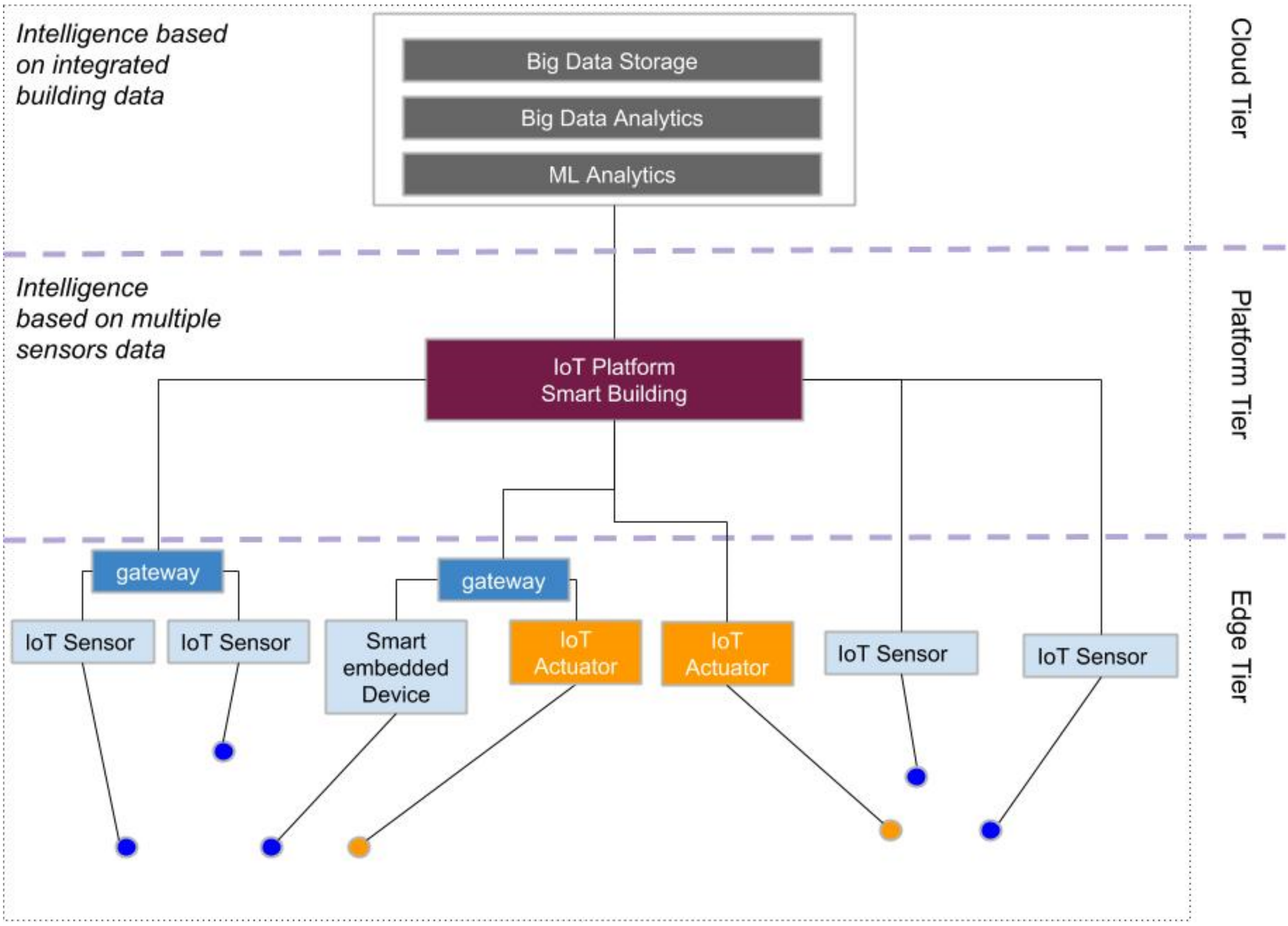


Figure 1 A general architecture of the ISI Pilot deployment

6 Pilot Deployment in Huetor Tajar and Agron, Andalusia, Spain

Both Agron and Huetor Tajar municipalities in Granada, Spain, aims to convert regular lighting facilities to LED lighting facilities with near zero light emissions to the sky, and conventional sportive facilities to innovative, more sustainable ones. Testing the pilot deployment under real conditions will allow possible replication of the experience in small and medium municipalities as well as provide policy-makers with decision support tools.

6.1 Summary of the pilot deployment

The pilot deployment in the case of Huetor Tajar municipality involves lighting and remote management of sportive facilities and interconnection of the system with other smart lighting systems already existing in the municipality. The pilot deployment in the case of Agron municipality involves lighting and remote management of a part of the public lighting facilities considering intelligent system to reduce energy consumption as well as nearly zero emissions to the sky

In both pilots, the system will deploy high-performance affordable technology to monitor and analyze the use and energy consumption of the fields with a goal to lower consumption without sacrificing light quality. The system will be replicable in other similar installations and scalable.

6.2 User requirements

Tackling each User Requirement introduced in Deliverable D3.2.1, a general description of their solution – and the reasons behind the adoption of these strategies – is presented:

- The smart management of lighting will be obtained by applying smart technologies combined with the dominant LED technology characterising this pilot deployment in both pilots Huetor Tajar and Agron.
- The system will actively control the lighting in order to reduce the overall energy consumption. In this way, the consumption will be reduced primarily by exploiting LED technology and secondly by exploiting smart control algorithms in both pilots Huetor Tajar and Agron.
- Panels, websites or applications will be used to spread the information on energy savings and other possible relevant results to the citizens in both pilots Huetor Tajar and Agron.

- To guarantee the system modularity and expandability – in both hardware and software – a new horizontal solution based on standards will be implemented in both pilots Huetor Tajar and Agron.

6.3 Functionalities

To fulfill the user requirements presented in the previous chapter, an overall strategy was presented in the previous section. This strategy is now developed into a detailed functional specification to accurately describe the proposed solution characterizing this pilot deployment:

- Smart technologies will monitor and analyse in real-time human motion and other trigger events to improve the system performances and efficiency while maintaining the same user comfort in both pilots Huetor Tajar and Agron.
- Beside installing LED technology, the proposed system will be able to actuate in the amount (and colour if possible in the case of Huetor Tajar sportive facilities) of the light in the facilities, and thus the system would control the energy consumption in both pilots Huetor Tajar and Agron.
- Different divulgation means will be studied and applied in order to deliver the consumption and efficiency information to the largest slice of population in both pilots Huetor Tajar and Agron.
- A new horizontal solution based on standards, such as FIWARE European standard, will be exploited in both pilots. Such structure could communicate with already existing systems. Moreover, a new vertical solution in the sportive fields would be implemented.

6.4 Devices and sensors

As described previously in the functional specification, the main devices involved in this pilot deployment are:

- LED technology for the lighting system
- Smart devices capable of measuring people occupancy and motion
- Actuation devices to control the intensity of lights
- Depending on the results of the study on information divulgation, monitors to display the achieved results

7 Pilot Deployment in Lyon, France

INSA Lyon pilot deployment is about creating an experimental urban area with smart digital solutions that will help improve the life of citizens, and that will contribute to reducing the energy consumption of the city due to smart public lighting. Algorithms and smart city related technologies will be tested in real life conditions, and under varying environmental conditions.

7.1 Summary of the pilot deployment

The pilot will be deployed on the Lyon Tech La Doua campus, a complex building system hosting numerous laboratories, companies and educational institutions, as well as supporting buildings. The pilot consists of an autonomous sensor network containing several sensors (e.g., motion, light, temperature) that will have the role of monitoring and recording the environmental conditions of the site, and a wireless network that will run different predefined use case scenarios and stress tests of the system. The pilot system will create an experimental testbed for testing the smart lighting system under different environmental and load conditions in real life applications.

7.2 User requirements

To tackle each User Requirement introduced in Deliverable D3.2.1, several scenarios will be performed as listed below:

- Gather environment information (e.g., temperature, humidity): using environmental sensor is planned, which are cheap and efficient.
- Gather information about people passing by: using motion sensors, which are cheap and efficient.
- Store gathered information locally: devices will be equipped with and SD card to allow storage of information in a safe and secure manner.
- Send commands to the network: devices will be equipped with a wireless long range radio chip, e.g., using the LoRa technology, which enable communication of several km.
- Ease of deployment: our deployment will be modular, thanks to its logical separation of the testbed into two different networks (a sensor network and a wireless network).
- Gathered information concerning lighting will be used for smart management of the required energy.

- The system will be used to perform several stress tests of pre-defined scenarios depicting possible harsh conditions applied to the pilot.

7.3 Functionalities

To specifically implement the solutions presented in the previous paragraph, a precise list of the functionalities introduces in this pilot deployment is given:

- People presence monitoring;
- Temperature and humidity monitoring;
- Light monitoring;
- Over the air parameterization of the network using a set of pre-defined scenarios;
- Energy consumption evaluation of a solution.

7.4 Devices and sensors

The functionalities presented in the previous section are performed by a specific set of equipment. Considering the high-level system structure, it is possible to distinguish between a sensor network and a wireless network. The sensor network will manage 15 devices composed of:

a. An enclosure
b. Batteries
c. Sensors: motion sensor, light sensor, temperature and humidity sensor
d. A single-board microcontroller (e.g., Arduino)
e. SD card and connectors

Further information about the sensor deployed in the sensor network are given in the list below:

- Motion sensor (e.g., 2-4 PIR AMN1 directional sensors per each device)
- Light sensor (e.g., one BH1750 sensor per each device)
- Temperature and humidity sensor (one DHT22 sensors per device)

The wireless network will manage 3 gateways and 15 devices composed of:

f. An enclosure
g. Batteries
h. Wireless communication board using LoRa radio technology
i. SD card and connectors

The testbed will exploit long range wireless technology (e.g., one SX1272 LoRa chipsets from Semtech per each device, 3 SX1301 based LoRaWan gateways for the campus) in the 868 MHz unlicensed band.

7.5 Data storage and analysis

Data collected by our pilot will be stored on our local servers and analyzed using statistical tools for networking and system performance evaluation. In particular, the aim is to bridge these data with a discrete event simulator for enabling reproducible scenario analysis.

8 Pilot Deployment in Pescara, Abruzzo, Italy

ABRUZZO REGION aims to create an experimental urban area on the Municipality of Pescara for deploying and testing smart and versatile digital Street lighting systems that will contribute to:

- reduce energy use
- manage, maintain, and monitor the entire system simply and efficiently
- reduce CO_2 emissions for a greener, more sustainable city

8.1 Summary of the pilot deployment

The pilot project intends to create an integrated system of Smart lighting along one of the main roads of Pescara, replacing the old lighting system with a new intelligent system effective and efficient, in order to evaluate the actual Saving of electricity through a combination of the brightness adjustment of the lamps to the conditions of environmental visibility and lighting management.

8.2 User requirements

The main goal of the pilot deployed by ABRUZZO REGION is to test a innovative system of point-point remote control that meets all managerial needs, aimed at a more rational use of economic resources and the improvement of the quality of the service offered to citizenship.

To achieve this, the service should meet the following User Requirements:

- **Enhance energy monitoring and management:** In order to enhance energy monitoring and management and to ensure control of environmental factors in smart street lighting, a system of sensors (detection of traffic flows and TVCC control) will be put in place subject to interventions.

- **Propose a vertical solution**: In order to the vertical solution proposed, the innovative system of point-point remote control allows from any Personal Computer connected to the Lan (or to the Internet) and equipped with Web browsers to command and interrogate every single cabinet and every single luminous point located on the communal territory. It represents the platform that through the conveyed wave technology enables the existing power line of public lighting installations to transmit high-speed data.

An electronic device to be installed in Series after the lamp protection fuse, and it will be able to diagnose the malfunction of the lamp and converse with the device Control/Command cabinet, receive instructions from the control device/Cabinet control to command Turning the lamp on or off, reducing or adjusting the luminous flux of the Lamp itself.

- **Inform the citizens**: In order to inform the citizens of the improvements achieved through technology, the monitoring system will be able to communicate basic data of interest of the citizens (traffic flows, energy saved) to an APP and/or physical device.

- **Replicability and scalability:** The solution respond to the User Requirement of replicability and scalability of the project, and thus be simple and easy to replicate to other small and medium municipalities (and by extension, to bigger municipalities). The system is designed to be installed on both large and small systems, and is structured in such a way that it can grow and be expanded as new needs arise, thus following the development of urbanization and satisfying the needs of each manager. The system is modular because it allows to manage part of the system, or even just some aspects of it, and - without having to change anything but only adding further components - it can be implemented and extended to the territory. Finally, each device can also be reprogrammed in the field by modifying the code and the operating parameters.

8.3 Functionalities

The system has the following functionalities:

CONTROL DEVICE AND CABINET COMMAND

It is made up of components to be placed in the Electrical Control Panel that feeds the lighting lines. It is able to:

- Dialogue using the existing power line, with conveyed waves, with the devices of control/Command lamp placed on the lamps supplied by the line itself;
- Receive all information relating to fault or anomaly states and transfer them via GPRS/TCP-IP to a remote supervisor for the management of collected data;
- Receive instructions via GPRS/TCP-IP from the remote supervisor and transfer them, in dialogue On the existing electric line, with conveyed waves, to all the devices

Control/Command lamp for controlling the switching on/off time or the Low-power operation of each individual lamp and/or groups of lamps;

- Carry out all the controls at the level of the electric panel and the supply lines communicating any anomalies via GPRS/TCP-IP to the supervisor for the management of Data or, in cases of particular gravity, directly to the personnel responsible for intervening, by SMS or call;
- Monitor possible theft of cables with the support of modules installed at the light point level
- Receive instructions from the supervisor, which you can access on your local network or Through the Internet, for the execution of power on/off commands according to programming from astronomical clock for daily programs, yearly, as well as for executing commands and activation controls auxiliary.
- Interface to any third party system via an RS485 line

CONTROLLER AND LAMP CONTROL DEVICE

It is an electronic device to be installed in Series after the lamp protection fuse. It is able to:

- Diagnose the malfunction of the lamp and converse with the device Control/Command cabinet, on the lamp power line;
- Receive instructions from the control device/Cabinet control to command Turning the lamp on or off, reducing or adjusting the luminous flux of the Lamp itself;
- Filter the noise generated by the lamp

SUPERVISION UNIT

It consists of a server machine operating on a Linux platform that Allows access via web browser to the management and control software of the systems Public lighting and associated sensors.

The application software, modular and customizable, is able to:

- Visualize all the malfunctioning events occurring on the systems, so for each individual distribution framework, starting line, lamp, accessory, highlighting the exact type and time of the event;
- Manually or automatically program the on/Off/reduction of all the lamps associated with the single switchboard;
- Manually or automatically program the on/Off/reduction individual lamps in a different way according to the needs of the operator or management.

- The application software, is designed to be easily customized to the needs of the Single handler. The transfer of information and the sending of configurations to the devices Control Panel can be carried out through different systems of communication (GSM/GPRS/TCP-IP).

The benefits of the system are as follows:

- Increase the efficiency and functionality of street lighting
- Expand the street lighting system by adding additional functions
- Provide a platform for future smart city applications.
- To design and execute the advanced development in embedded system for energy saving of street lights.
- Collect data from city street lights in order to monitor and optimize the street lighting efficiency.

To adopt a suitable distributed embedded infrastructure

8.4 Devices and sensors

The pilot project plans to implement a new system composed by:

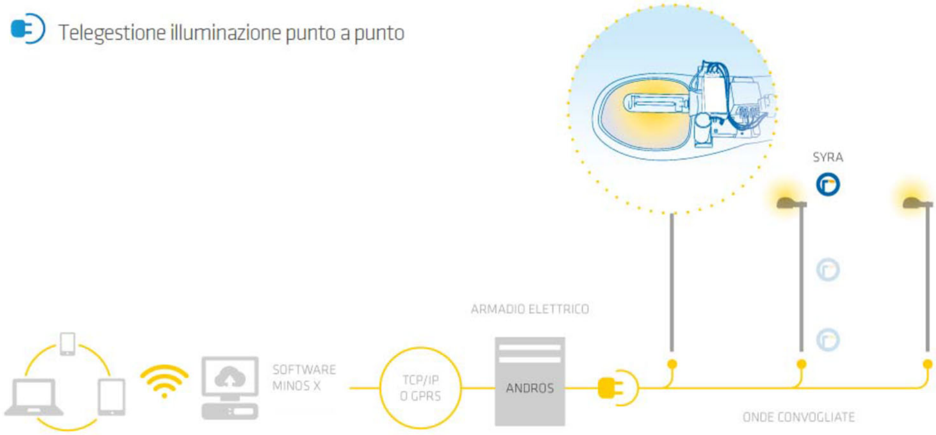
- 20 LED street lamps with Controller and Lamp control device

- 1 Electrical Control Panel that feeds the lighting lines, with Control device and Cabinet command

- 1 system of 2 CCTV cameras with PowerLine transmission that allows you to transfer your Video signal of a camera using directly the 230vac power supply line of the public lighting system

- 1 wave remote control system with sensors for the detection of traffic flows

- 1 Supervision Unit,



8.4.1 Compatible System Components

8.4.1.1 Controller and lamp control device (20 pieces)

It allows to monitor all the parameters of each single light point such as: current, voltage, power factor, active power, lamp status, LED temperature.

The remote control device allows you to control the switching on and off of the lamp and to adjust the luminous flux in order to check the energy savings, thanks to the innovative and reliable control system that controls the correctness of the set value; moreover it is the only device that can be equipped with a temperature probe and then automatically regulate the luminous flux in case of exceeding the set temperature threshold (option applicable only in case the temperature control is not already foreseen by the electronic ballast).

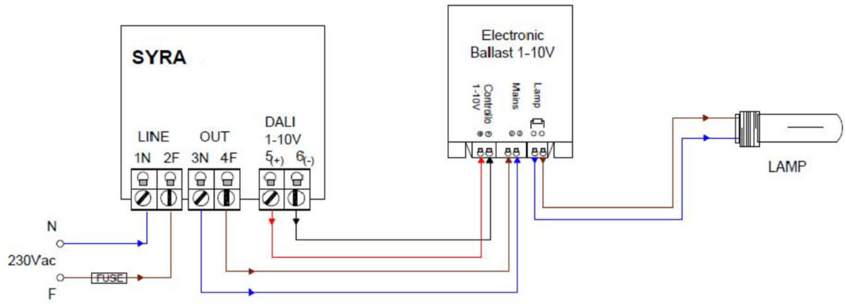
A further feature that makes it unique is the stand-alone operation, without the need for additional devices at the square level: it automatically determines the time and allows you to set up to 3 timers corresponding to different levels of lighting.

Depending on the profile set, even in stand-alone mode, large savings can be made.

It is able to manage the dimming command for LED lamps with electronic ballasts with standard 1-10V and PWM. ei.LED-T controls LED lamps with power from 20W to 250W.

It can also take measurements of electrical parameters and transfer them to the control module.

The accuracy in the reading depends on precision in the measurement and on the full scale used: 2% on current measurements, <1% on full scale power measurements.



8.4.1.2 Electrical Control Panel (1 piece)

The device / s to be installed in the control panel has the following technical characteristics:

• it guarantees the management of the public lighting control panel by checking the individual lighting points and archives the collected data and sends them via GPRS / TCP-IP to the supervision station represented by the server, or by the possibility of integrating the system with a Local PLC via 485 protocol on modbus.

In particular, the CPU module makes available:

• Two digital inputs for monitoring cabinet states

• A relay output for activating loads

• Digital inputs and outputs (max 16 additional modules)

• Analogue inputs and outputs (max 16 additional modules)

• Possibility of interfacing with up to 16 three-phase network analyzers using an RS 485 port

• Possibility to dialogue with any control panel PLC via RS485 port mod bus protocol

• Management of real-time diagnostics of lighting points

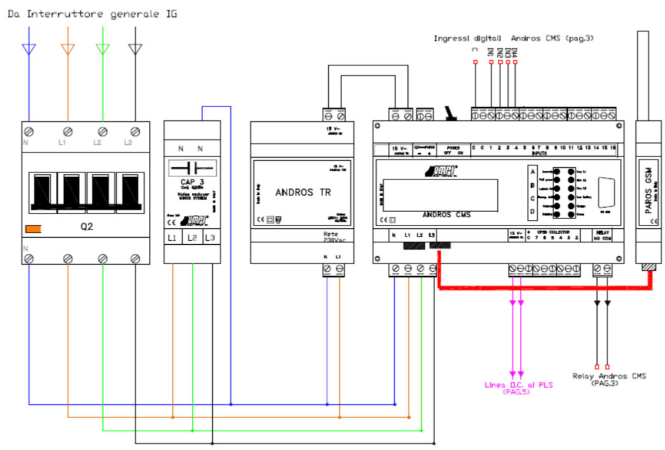
• Management of the dimming level of the single light point by means of user-defined profiles or by commands received from the possible control panel PLC

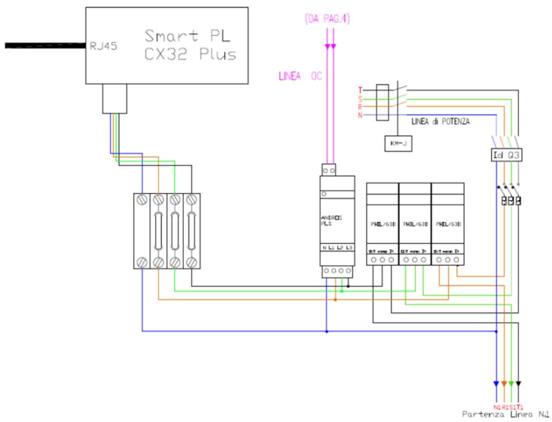
• Possibility to identify a situation of cable theft and to understand the point of cuts according to the indications of the modules installed at the light level.

• Astronomical clock configurable by user;

The control unit also guarantees, in case of activation of an event on one of the connected lamps and consequently at its end, the storage in the archive of the event, the eventual closure or opening of relay outputs, the activation of calls on at least three stored telephone numbers.

The type of installation of the devices at the frame level is shown below in the case management through local supervision server, remote and through PLC. The switchgear devices can also be configured with stand-alone functionality that guarantees system functionality (switching off dimming etc ...) even without supervision systems.





8.4.1.3 Control device and Cabinet command (1 piece)

ANDROS CMS –CPU MODULE

The command and control module manages the Andros modules and communicates with the IOS server.

Collects, processes and stores information and signals at the panel and lamp levels from the peripheral modules (SYRA).

It executes commands based on a schedule recorded in non volatile memory and configurable by remote supervisor. Dialogue with the local terminal via RS232 connection and with the IOS server via GSM / GPRS / TCP-IP or other protocols. It can manage up to 1022 control and lamp control modules (SYRA) per panel.

ANDROS PLS –POWER LINE MODULE

The Power Line communication module monitors and manages the presence of voltage on a more neutral three-phase line. Managed by the control unit / control unit (ANDROS CMS), it is able to control up to 1,022 control and lamp control modules (SYRA) on the same power supply line as the lamps.

Andros CMS can control up to 15 Andros PLS powered directly and / or via an additional power supply (Andros TRS).

ANDROS TR – POWER SUPPLY MODULE

The power supply module for devices IS connected to the electrical panel and can power the Andros CMS control unit and up to 5 Andros PLS modules. If the Andros PLS modules are more than 5, an additional power supply must be provided (Andros TRS)
Power module for devices connected to the electrical panel.

PAROS – MODEM GSM/GPRS

The GPRS communication module for transmitting the control data flow, measurements, security and signals on the GPRS infrastructure is used as a communication module between the remote supervision system (IOS Server and MINOS-X Software). It is connected to the Andros CMS nodule via a modular RJ45 socket and is powered at 5Vdc. Inside it must be equipped with a SIM CARD GPRS with data traffic contract. The connection parameters that the device uses are stored in Andros CMS.

Technical features:
• Power supply: 5Vdc +/- 10% (from Andros CMS)
• Current consumption (at 5Vdc): 520mA
• Operating temperature: -30 ° C + 65 ° C
• Electrical insulation: Class III (very low voltage systems)
• Degree of Protection: IP 20
• Dimensions: 17.5 x 90 x 70 mm (1 module - DIN)
• Weight: 15g.

8.4.1.4 Monitoring equipment (1 piece)

<u>TVCC CAMERA SYSTEM</u>

The TVcc camera system with transmission on PowerLine can allow the video signal of a camera to be transferred, positioned at the most appropriate point, directly using the 230Vac power supply line of the public lighting system.
This solution is particularly useful when you want to install cameras outdoors, such as along city streets, in public parking lots, etc. In these cases it is possible to exploit the same power supply line as the public lighting street lamps to power and connect the cameras. In order for the cameras to work even during the day, the public lighting lines must be managed and enabled by a remote control system, which allows the use and adaptation of the power lines to the Powerline transmission.
The system consists of IP-type digital cameras, integrated with a special converter / modem on the PowerLine network. The device allows to convert the video stream from a signal on an Ethernet network to a signal on a power line, to implement.
On the electrical panel, or near the node connecting the remote transmission line, the PowerLine video signal is converted into the Ethernet standard.
The reconversion takes place by inserting on the power line a special device able to aggregate the flows sent by the cameras and to manage all the Powerline connection parameters.
The conversion device between Power Line and Lan can be directly integrated with other devices.

DETECTION OF TRAFFIC FLOWS

On public lighting systems equipped with the telecontrol system with waves conveyed and enabled to value-added services it is possible to install sensors for the detection of traffic flows: in a non-invasive way, without affecting the road surface, the sensors count the vehicles transiting in both directions, distinguishing 3 categories (motorcycles, car trucks) and detecting the overall average speed.
All the data collected are communicated via the power line, with the conveyed wave technology, to the concentrator system, located inside the electrical panel: from this, then, the data they are forwarded to the supervisory web system that allows, therefore, to view hourly and daily statistics, to export data, to check the status of each road and also of the device same (self-diagnostic).
The main features are:
• Monitor traffic on urban and extra-urban roads
• Classify transit by type of vehicles
• Analyze data for each individual road and direction of travel
• Extract the data and export it to other systems
• Have useful elements to better govern the territory
• Save energy based on the number of transits in each time slot, weekly etc.
• Create smart lighting control (reduction) scenarios

8.5 Data storage and analysis

The management and supervision server is complete with software for displaying all the events related to the cabinets and is enabled to display all the events related to the lamps controlled by the system.
The operating system used is Debian Linux, which guarantees high reliability, immunity to computer viruses, de facto standards for web applications and security.
The server machine integrates a 56K RTC modem to allow maintenance and operations remote management when not published on the internet.
The server machine integrates a GSM / GPRS modem for data connection with CSD protocol to remote-controlled electrical panels via GSM / GPRS modem.
The server machine has a display showing the main information without the need for access via software such as:

- GSM / GPRS modem status
- GSM / GPRS signal quality of the modem on board the server
- IP address of the machine
- indication of "heart beat", which indicates that the server is running

The supervision server integrates a DBMS (Data Base Management System) able to memorize data in a persistent way, organized according to a relational model with unique indexes and access keys.
The system also allows periodic backups of data collected in the field and contained in the DBMS, so as to ensure the maintenance of the history both locally and on different computer media (transfer via FTP to other machines, for example), a period of over 5 years.
The system can be expanded with a data export module in open XML format, which guarantees interaction with other possible software for data management, consistent with the logic of Open Data.

9 Pilot Deployment in public buildings in Milan, Lombardy, Italy

The Metropolitan City of Milan aims at creating a system of smart devices in order to enhance applications and services for citizens. The pilot will allow for the finalization of an innovative fiber-optic infrastructure that will improve public buildings and schools in the metropolitan area.

9.1 Summary of the pilot deployment

The pilot deployment involves setting up a fiber-optic infrastructure in certain rooms of Palazzo Isimbardi, which serves as the headquarters of the Metropolitan City of Milan. The system will be used to monitor and control environment parameters in the rooms. A similar system will be setup in a school building in the metropolitan area.

Through use of the deployed system energy management in public buildings will be enhanced and the artistic and cultural heritage of the Metropolitan City of Milan will be safeguarded. Moreover the selected buildings will be monitored in real time and smart control algorithms to optimize energy consumption and user's comfort will be created and tested.

9.2 User requirements

The User Requirements described in Deliverable D3.2.1 are to be tackled in a comprehensive manner.

In order to enhance energy monitoring and management and to ensure control of environmental factors in public buildings, a system of sensors (both in optic fiber – fiber Bragg Grating (FBG) sensors – and with a LoRaWAN network) will be put in place in the buildings subject to interventions.

In order to optimize energy consumption and users' comfort, the monitoring system will be complemented by a system of actuators that will allow the modification of certain environmental characteristics in the buildings. Moreover, an air purifier based on a bioreactor will be installed for the purpose of destroying polluting particles with a minimum energetic consumption. This purifier will improve the air quality thus reducing the need for fresh air (and therefore decreasing energy consumed for heating or cooling the air). Additionally, measuring the benefits in terms of air decontamination will allow to cross-check the data from all other measured quantities and verify improvements in terms of energy savings. All data from the different sensors will be directed and stored in an applicative in-cloud platform.

Finally, the integration of the two types of sensors (in optic fiber and with LoRaWAN network) exemplifies the adaptability of the envisaged solution to different situations and buildings. This responds to the User Requirement of replicability and scalability of the project. The extension of such a system to other public entities and buildings in the territory will create the pre-conditions for the sharing of data on the topic of energy efficiency and management and thus enhance the system of *open governance* and diffusion of innovation among entities.

9.3 Functionalities

The pilot project will allow to install different systems in heterogeneous contexts, thus introducing various functions: **monitoring of environmental and structural characteristics of the buildings**, though both the optic fiber sensors and LoRaWAN sensors; **energy monitoring and control** in order to identify excessive or anomalous energy consumption and start actuators accordingly; **people presence monitoring** in the premises, again to limit energy consumption; **air purification** to control energy consumption and to improve users' comfort.

9.4 Devices and sensors

The **fiber Bragg Grating (FBG) sensors** installed within the optic fiber will be able to measure temperature, humidity and vibration. The proposed number of sensors are: 3 sensors for temperature and humidity (all-in-one); 3 sensors for temperature; 1 sensor for vibration. The sensors will have the following characteristics:

- Measurement range: +/- 10 g
- Bandwidth: 0 to 50 Hz (resonance typ. - 430 Hz)
- Sensitivity: typ. 75 pm/g
- Resolution: 12.5/sqrt (Hz)
- Operating Temperature Range: -20 to +80 °C
- Mass: 250 g
- Sensor construction: steel or polymer tubing with sensing fiber loose inside

- Temperature sensitivity: 11 pm/°C
- Measurement resolution: 0.05 °C
- Measurement accuracy: 0.1 °C
- Measurement range: -20 to +80 °C

The system of sensors will be complemented by one **4-channel optic fiber illuminator**.

The **LoRaWAN sensors** will be directed at measuring: presence of windows or doors that are open or closed; number of people in the room; movements in the room; brightness; measure of day-time light. All-in-one sensors will be preferred, but their exact number is still to be defined.

A **real-time measurement system** will be implemented for the energy consumption of devices connected to the electricity grid. The system, through an appliance mounted in the electricity metering and connected to the phase (single or three-phase), will allow the analysis of the different types of consumption and suggest possible improvements.

Finally, one **air purifier** will be installed in the premises to improve air quality and energy efficiency. The air purifier is based on a bioreactor capable of destroying contaminants with minimal energy consumption. The central element of the solution is an additive based on non-pathogenic micro-organisms, not genetically modified, and enzymes in a completely natural formula.

9.5 Data storage and analysis

The already mentioned in-cloud platform for collection and storage of data will be installed in system of virtualized servers. This method will improve the scalability of the processing capacities and also the reliability of the system. Moreover, the system will send a periodic report with a breakdown of electrical devices, with data on costs and consumption to analyse trends and identify the most energy-consuming devices.

10 Pilot Deployment in a university building in Milan, Lombardy, Italy

The pilot in Politecnico di Milano aims at managing the thermal network of a smart school building for monitoring, validation and analysis of different modeling approaches for building thermal energy analysis and also deploying and testing several control solutions in the context of classic to advance methods. Experiments with different energy efficiency scenarios in real life conditions will be held.

10.1 Summary of the pilot deployment

The pilot will be deployed in an existing school building equipped by different type of heating and cooling systems together with several energy resources ranging from thermal to electrical energy generators and storages. The building is situated in Milano Leonardo campus of Politecnico di Milano. The system, after the deployment of the pilot, will also include all required sensors, actuators, data loggers, computers and interfaces for data acquisition.

The pilot aims to analyze proposed modeling and control strategies as well as energy consumption and performance of different systems in the building. The pilot will be used to deliver smart monitoring and control solutions integrating energy consumption and user comfort optimization

10.2 User requirements

To tackle each User Requirement introduced in Deliverable D3.2.1, several scenarios will be performed as listed below:

- Changing of the heating/cooling loops based on different apparatuses installed in the testing building, such as radiant floor heating or cooling, ceiling fan coils for heating and cooling, using different combination of the heat pumps and collectors systems, using heat pump connected to thermal energy storage and so on.
- Investigation of the effects of the occupant behavior by using people presence monitoring system in order to model their behavior and apply it into the control system to illustrate how big is its effects on the energy consumption, level of comfort and control performance.
- Several modeling techniques can be exploited to address a dynamical model of the system. The proposed modeling techniques in the context of both control-oriented models

and models for energy analysis can be experimentally validated by using the real data recorded by multi tasks monitoring system. These models are capable to estimate or predict the energy consumption of the system in future based on different materials, different structural changes, different HVAC systems and even several control schemes. It can show us, how long is the reimbursement of the investment and how big is the benefit under the specific changes in the building.

- Different control strategies in the context of classic control approaches and advanced methods will be designed and experimentally tested. Model predictive control techniques can be in the category of the advance modelling approaches which is derived based on the proposed validated models. On the contrary some data-driven control techniques can be performed using the real data recorded by data acquisition system.
- The management of all the degrees of freedom of the complex thermal network for load shaping in demand side management can be investigated. It gives the possibility to shape the demand profile in an economic way based on dynamic electricity tariffs, by storing energy in thermal terms during off-peak hours. Moreover, some advanced control frameworks, for instance Model Predictive Control (MPC), will be considered to better anticipate the effects of disturbances (e.g. weather conditions and user requirements on the load side, electricity price, etc.).

10.3 Functionalities

Several quantities have to be measured and recorded in order to perform each scenario introduced in the previous section.

There are a number of quantities inside of the building which have to be measured to fulfill the user requirements. This function will be executed mainly by the pre-existing equipment in the testing building.

Moreover, in the plant side, i.e. heating/cooling system, power generators and storages, a comprehensive monitoring system will be refined for measuring the following quantities:

- power production of renewable generators (PV panes)
- power frequency and electrical power consumed by heating/cooling system
- temperature of the water inside of the heating/cooling pipelines
- temperature of the water in different layers of the water tank
- cop of the heat pumps
- water flow rate in different point of the system

A weather station is required for measuring outside weather temperature, humidity and wind speed. These quantities are capable of improving the results coming from the real experiments.

In addition, an online communication interface is required between the user and programmable controllers in order to change all settings of the system for performing different experiments. Supervisory control and data acquisition (SCADA) system will be utilized for networking all peripheral devices such as programmable logic controllers and discrete classic and advanced controllers and monitoring system in order to interface with the process plant or machineries.

10.4 Devices and sensors

To tackle each scenario introduced in the previous section, a comprehensive monitoring system together with a fully equipped smart building with different HVAC systems and actuators and power generators are required. Therefore, a list of required sensors, monitoring devices and components are provided as follows. Most of the presented devices are already equipped in the testing building:

Monitoring equipment (sensors):

- Weather data
    - Outside temperature
    - Solar radiation
    - Wind speed
- Building temperature
    - Building air temperature
- Flow rate
    - Water flow rate passing through building pipelines
    - Refrigerant flow rate passing through HVAC coils
- Power consumption of electrical equipment
- Humidity
- Human Presence

- Data logger

General components

- Heat exchanger coils
- Heat pump for cooling and heating
- Renewable energy (solar panels)
- Air handling units
- Different collectors and hydraulic separators

11 Pilot deployment in Lisbon Metropolitan Area, Portugal

The main goal of the pilot is to install energy consumption smart metering system in public buildings in ENA's Municipalities (Palmela, Setúbal and Sesimbra). A system will be installed to monitor, control, optimize and test energy parameters enhancement through an ecosystem of smart devices for smart urban living. Those systems will provide data for the Municipalities and their citizens.

11.1 Summary of the pilot deployment

The pilot will be deployed in 24 Municipalities' public office buildings in Palmela, Setúbal and Sesimbra. The smart metering equipment will be installed in the main power line of each building to monitor energy consumption in real time. Analysis of the acquired data will be used to plan needed interventions and deliver energy patterns to optimize the energy consumption of buildings.

11.2 User requirements

The user requirements related to this pilot deployment have been listed down in Deliverable D3.2.1. Referring to those specific requirements, a general description of the strategy deployed to meet them is proposed:

- *"Collect energy consumption data":*
  To perform this task, the energy consumption data will be collected at the energy entering point of each building.

- "*Provide a real-time analysis tool aiming at planning interventions and investments based on evident needs*":
  Affordable Information Communication Technology will be exploited to monitor in real-time the behavior of each analyzed building. Then, an online access to the data will guarantee the possibility to plan the required interventions.

- "*Define energy patterns to optimize the energy consumption*":
  Specific algorithms will be developed to research these efficient patterns by analyzing the

data collected by the previously proposed solutions.

Into fulfilling all the previous points, a particular attention will be given so to develop the previous solutions in a scalable and replicable fashion.

11.3 Functionalities

Entering into detail on the previously proposed guidelines, a specific list of functionalities introduced in this pilot deployment context are presented:

- Specific metering equipment will be installed in the energy entering point of each building, in order to monitor in real time the consumption of each of the 24 buildings.
- A dedicated network will be set-up in order to centralize the collection of such real-time measurements
- A web monitoring platform will be developed, which will be able to report on major events and necessities to plan specific interventions
- Algorithms will be studied to detect efficient energy patterns aiming at optimizing the overall energy consumption of the 24 buildings

11.4 Devices and sensors

To fulfill the functional specification regarding the energy consumption real-time monitoring, 24 different metering devices will be installed at the entering point of each building.

These metering devices will be then connected through a dedicated network in order to centralize the connection and data transfer to a main collection point.

11.5 Data storage and analysis

After each of the 24 metering devices collects the aforementioned real-time data, the data will be collected in a single storage system. A web monitoring platform will be able to connect to this centralized database, in order to offer the user a report platform on the real-time status of each building and any eventual necessity of planning an intervention.

The data analysis will be concerned even in the development of specific research algorithms, which will search for any lead on defining an efficient energy consumption pattern as specified in the user requirements list.

12 Common User Requirements for all Pilot Deployments

Certain user requirements are shared between all pilot deployments. These requirements, being more general, are applicable in almost all cases, whether they utilize the theme of “Building Energy Efficiency” or “Smart Public Lighting”. A brief description of each requirement is presented in the following paragraphs.

All pilot deployments must be replicable to allow for the application of the proposed solution to other similar cases. Moreover all deployments must use the most innovative and cutting edge technological solutions to highlight their advantages. All solutions will utilize open source software wherever possible, which also makes it easier for the solution to be replicable. The project will use smart devices to achieve the expected results. These devices can be sensors, actuators or embedded devices that enable different data acquisition and control scenarios. Through intelligence and utilization of computational resources of devices at the edge of the system the project will promote the experimentation of all deployments at the edge level. With the exception of Politechnico di Milano, all other partners intend to use cloud based services for data storage and analytics. Another important point is for the captured data to have the highest possible quality, in both time and special context, to allow for more accurate results from the performed analysis.

All devices and systems used in the pilot deployments will be selected based on their ease of use and installation, as well as their durability, which is translated as an ease in inspection and maintenance of both software and installed equipment. It is critical for the project that all installations and used software does not create any privacy or legal framework concerns. Furthermore, since deployments are performed mostly in public buildings and spaces, it is important to have minimal intrusion in the surrounding environment and to have aesthetics as pleasant as possible. Finally, the total cost of each deployment, in terms of acquisition, installation, and maintenance, is an important concern to be addressed by the project.

13 Conclusions

Deliverable D3.2.3 presents an Operational Plan Framework for the Pilot Deployment use cases of the project. The overall project delves into two areas related with the Smart City concept, namely the “Building Energy Efficiency” and “Smart Public Lighting” themes. Pilot programs will be deployed in several areas designated by the involved partners, each targeting one of the two themes mentioned previously.

The deliverable uses as input the user requirements of each deployment area and the functional specifications derived from them in Deliverable D3.2.1 and lays out the necessary framework for each deployment use case. This framework covers the functionalities implemented in each pilot area, together with a case specific technical approach on sensors and other devices to be used and the data storage and data analytics to be performed.

Together with Deliverables D3.2.1 and D3.2.2, this deliverable is used as input to Project Activity 3.3 dealing with Pilot Testing.

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