ESMARTCITY

Enabling Smarter City in the MED Area through Networking

Deliverable 3.3.1 – Pilot deployment

Delivery Date: 27.11.2019

Author: Alessio Caroppo

Supervisor#1: Gino Verrocchi

Supervisor#2: Laura Antosa

Project Coordinator: **Iris Flacco (LP – ABREG)**

Dissemination Level		
PU	Public	X
PP	Restricted to Programme Partners and MED Programme	
RE	Restricted to a Group defined by the Partnership and MED Programme	
CO	Confidential, only for members of the partnership and MED Programme	

Content

Project co-financed by the European Regional Development Fund

Project co-financed by the European Regional Development Fund

1 Vision of Smart Abruzzo Region

1.1 Abstract and Keywords

The Vision of Smart Abruzzo Region is a general strategic decision of the Abruzzo Region and its Department of Energy Policy, Air Quality and National Environmental Information System (SINA) as the partner in the EU Intereg MED Esmartcity project. This general strategic decision aim to contribute to improve the city lighting management providing policy makers, PA and energy managers with decision support tools to optimize environmental impacts of their decisions and operations. In particular, Abruzzo Region aimed to create an experimental urban area on the Municipality of Pescara for deploying and testing smart and versatile digital Street lighting systems, to gather all these goals.

The pilot Smart Street Lighting in Pescara 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.

The Feasibility study, Methodology for Testing and Pilot Deployment Operational Plan Framework defined the most important goals for the implementation phase and the verification process. The projectis aligned with the most important global strategic documents as theEU Digital Agenda 2020 and the UN Sustainable Development Goals Agenda 2030, as the Goal 11: "Sustainable Cities and Communities".

1.2 General Concept of Smart Cities

An acceptable definition of Smart City is the following: "A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance "To address these challenges and capitalize on the opportunities, cities are encouraged to become "*Smart Cities*". (1)

With the current urbanization trends, new challenges for advanced services offered born. Therefore, there is the necessity to offer new advanced services to city.

All these services consider the use of smart technologies and data as the means to solve cities' sustainability challenges – economic, social and environmental issues. In particular, the main technological buildings blocks behind the Smart City paradigm comprise:

- devices, smart devices and more generally "things" deployed at a large scale and having adequate embedded computational capabilities to contribute to a pervasive computing paradigm,

Project co-financed by the European Regional Development Fund

- Ubiquitous high speed networking infrastructure connecting people, places and things and utilizing its networking forerunners of the Semantic Web and the Social Web, and
- Data management, Ambient Intelligence and Data Analytics enabling highly autonomous decision making.

Smart technologies concern in ICT solutions, and, in wide range, in Internet of Things (IoT). They range from expensive hardware solutions such as city control centers, smart grids and autonomous vehicles, through to much lower cost solutions such as smartphone apps, online platforms etc.

The Internet of Things (IoT) is the term used as an umbrella keyword for covering various aspects related to the extension of the Internet and the Web into the physical realm, by means of the widespread deployment of things, i.e. spatially distributed devices with embedded identification, sensing and/or actuation capabilities (2). The term things refers to anything from sensors and machines to entire buildings, and can include any device capable of participating in a communicating–actuating network, wherein sensors and actuators blend seamlessly with the environment, and the information is shared across platforms in order to develop a common operating picture (3). Most IoT devices are connected together to form purpose-specific systems, meaning that they are less frequently used as general-access devices on a worldwide network (4).

1.3 The State of City of Pescara: Challenges and Opportunities

The City of Pescara is an Italian municipality of 120 151 inhabitants, capital of the homonymous province in Abruzzo. In Abruzzo Region there are 4 provinces (L'Aquila, Teramo, Chieti and Pescara) and 305 municipalities, with 1500000 inhabitants. The Region has a surface of 10,794 km^2 and it is prevalently mountainous (65,1% mountainous, 34,9% constituted by hills).

Pescara is the most populous municipality in the region and is the heart of a metropolitan area of more than 250,000 inhabitants with adjoining municipalities and up to 420,000 including the entire area of influence.

The city is crossed entirely by several parallel road axes in a north-south direction; the principal of these is the SS13 (via Nazionale Adriatica Nord, viale Bovio, Corso Vittorio Emanuele II, viale Marconi, via della Bonifica) and the seafront promenade (lungomare Matteotti e viale Primo Vere). The pilot project developed along a stretch of about 400 meters of Viale Primo Vere Road.

Project co-financed by the European Regional Development Fund

Figure 1.1: Pescara, Viale Primo Vere

In the last years the city has been involved in a work of revitalizing the urban layout of the city, restoring the use of abandoned historical areas and buildings, carrying out many projects such as extending the pedestrian area of the central areas and creating a network of trails cycle paths. In 2009 the city hosted the XVI edition of "Giochi del Mediterraneo" (5).

2 Summary of the Pilot Deployment

The ESMARTCITY pilot is located in the Municipality of Pescara. The existent lighting public system in Pescara consist in lighting fixtures with glass cup, discharge lamps, ferromagnetic ballasts, absence of remote control technology, low energy efficiency.

The scenario where pilot is located along a stretch of about 400 meters of "Viale Primo Vere" Road: this is an high-haul road with a seasonal character with obsolete plant equipment, presence of cycle/pedestrian path, high pedestrian frequency with a seasonal character. This place offer the possibility to compare consumption with previous obsolete technology, the possibility to compare consumption with a similar redeveloped road section and the integration with video surveillance system under construction.

The area of intervention of the project falls on the IP plants in the northern waterfront area - EP001 (one of the 280 plants of the City of Pescara). The activity concerns QE01 electric cabinet, in Viale Primo Vere.

Project co-financed by the European Regional Development Fund

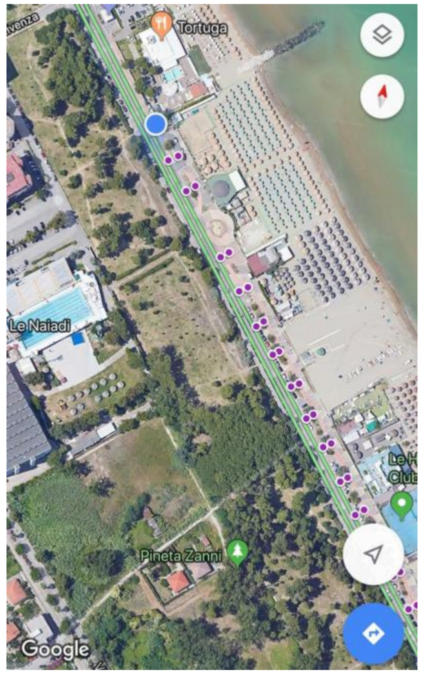


Figure 2.1: Area of interventation – EP001 - Viale della Riviera

With ESMARTCITY project the more efficient system (obtained by the substitution of old lamps with LED fixtures) is integrated in a smart mode, that include smart meetering and additional services. This integration of the deployed pilot system includes other fixtures and services also, to create a smart System, that concerns:

- a remote control unit for each light point to be managed, which allows the management of the lamp and the connection to the other light points;
- a network of environmental sensors;
- a video surveillance system with conveyed waves;
- a data collection unit for the network of sensors and light points, which allows dialogue with the control centre;
- a control centre for the management of lighting points.

System network communication uses the conveyed wave transmission technology. Through this technology, the system of fixtures predicted communicates with the single lamp using only the existing electrical network, without the addition of additional wiring. This technology allows flexible switching on, switching off or reduction of the luminous flux, as well as receiving a series of information deriving from the aforementioned luminaires. Everything is controlled and managed through the integration of a software, able to offer the advantages of the internet: the web-based software allows you to view all the data monitored by the hardware performed previously in the local LAN or in Cloud mode. The communication of the software with the control panel (ANDROS device) takes place via GSM, GPRS, 3G, LTE or TCP / IP communication for point-to-point remote control of the single lighting apparatus. Details of the communication system are given in following chapters.

2.1 Motivation

The principle motivation of this project is that a first step to create a smart city is installation of smart streetlights. By this way, the creation of a smart lighting system involves into a smart street network. In addition to more efficient lighting fixtures, smart street consists of security cameras, environmental sensors, traffic monitors, as well as an embedded electric vehicle (EV) charger installed. By this way, Smart City concept transforms digital technologies into better public services for citizens, better use of resources and less environmental impact.

The motivation can have various aspects, from environmental to economic. In environmental view, it can be observed that in the last decade there was a growing interest in the study of light pollution: this study extends from established areas of concern such as reduced visibility of the night sky or energy wastage, to an emerging emphasis on biodiversity loss, the disturbance of circadian rhythms, and the expansionary dynamics of global capital (6). Light pollution include several different phenomena including “light clutter,” when a myriad of different sources can cause disorientation, “light trespass” from unwanted light sources, and in particular “skyglow” produced by the scattering of light in the atmosphere where the cumulative impact can reduce night sky visibility over vast areas (6). From an economic point of view, street lighting is an essential community service that currently require to municipalities to spend up to 40% of their allocated budget. (7). A solution is replacing old lighting public fixtures with LEDs can reduce municipality’s energy bill by half. Integrating this innovative lighting LED system with networking and intelligent control (as video surveillance, remote and automatic control of lighting flux depending from environmental condition) can provide a 30% in saving energy and cost. In addition all these factors can enhance public safety, traffic management, health, comfort, and more (8).

2.2 Pilot Definition and Goals

Abruzzo Region aims to create an experimental urban area on the Municipality of Pescara, in one of the public lighting plants. This experimental area, that is the pilot, aim to deploy and test 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

Project co-financed by the European Regional Development Fund

This is possible by creating and integrating a 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.

The principle objective of the pilot is to test this innovative system, made up by point-point remote control that meets all managerial requests and need, for a more rational use of economic resources and the improvement of the quality of the service offered to inhabitants. This is possible by enhancing the energy monitoring and management, ensuring the control of environmental factors in smart street lightings: this is an installation of a system of sensors for detection of traffic flows and TVCC control.

Another requirement for the pilot's goal is the proposal of 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 of the plant 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. Installing electronic devices in Series after the lamp protection fuse, it's possible to detect malfunction of the lamp; in this manner the lamp communicate with the Control/Command Centre, receive instructions for this for turning the lamp on or off, reducing or adjusting the luminous flux of the Lamp itself in function of real environmental scenario.

Such a system allows to create a correct information to the citizens. In order to inform them of the improvements achieved by this technology, the monitoring system have to be able to communicate basic data of interest in a friendly-user mode, such as traffic flows and energy saved, to an APP or a platform. An existent web-platform, used in Pescara for the monitoring and management of all the plant of public lighting, can be used for this goal.

Finally, an important aspect is the data storage and analysis. Collecting the data from the Intelligent and Smart Public Lighting system in Pescara allows optimizing working regime of the system aligned with real environmental condition. The management and supervision server integrated by a software display all the events related to the lamps controlled by the system.

3 Pilot Implementation

3.1 System Architecture

The Smart Public Lighting system is designed to meet the User Requirements from the EU Interreg MED Esmartcity Pilot Deployment Operational Plan Framework for Pescara Municipality (9) and all main goals are met.

Project co-financed by the European Regional Development Fund

In this chapter, it will be described the implementation process, hardware and software components, sensors and measurement methodology, wireless communications backbone system, data centers and other system components.

The system is designed from its User Requirements, represented by main goals to achieve, and Functionalities, as the technical parameters.

A basic scheme of the system elements is represented in Figure 3.1.

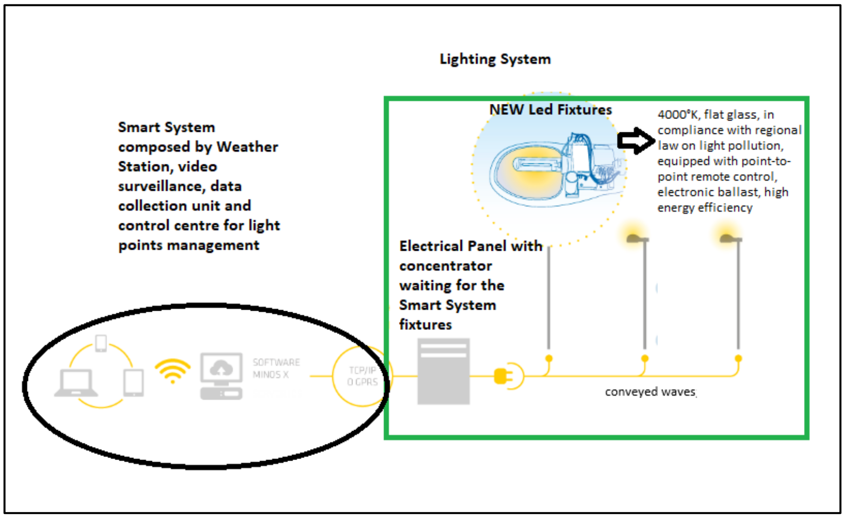


Figure 3.1: Basic Smart Scheme, with

The system, which will be described in the next chapters, is composed by a first part about the usual lighting system, with lighting fixtures (LEDs) more efficient than old lamps, and a second part, that integrate the first: the last is the Smart System, made up by all smart components (Weather Station, video surveillance, etc.).

The communication between the two parts of the system is with the conveyed wave technology.

3.2 User Requirements

The main goal of the pilot deployed by ABRUZZO REGION is to test a innovative system of pointpoint 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,

Project co-financed by the European Regional Development Fund

a systemof 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.

3.3 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/TCPIP to a remote supervisor for the management of collected data;

Project co-financed by the European Regional Development Fund

- 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

Project co-financed by the European Regional Development Fund

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.

3.4 Communications System Architecture

The communications system has an important role in a complex system as the Smart Public Lighting system. The communications system is designed to serve the EP001 plant of the Pescara Smart Public Lighting system now, but it is also replicable to other small and medium municipalities (and by extension, to bigger municipalities).

The system is designed to be installed on large and small systems, and is structured in such a way that it can be expanded as new needs arise, thus following the development of urbanization and satisfying the needs of each manager. In addition, the system is modular because it allows to manage part of the system and 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.

The principle technologic solution of the pilot is based on the "powerline" technology conveyed wave transmission technology) for data and info transferring, through the existing electricity network. This technology, applied to public lighting systems, allows complete and timely management of the plant. Potentially this technology makes it possible to manage up to 1022 peripheral devices with each individual concentrator, specifically up to 1022 public lighting lamps. This Powerline communication uses transmission frequencies at 111KHz and complies with CENELEC standards in Band B.

The specific project also uses a "Broadband" Powerline communication, therefore with greater bandwidth availability thanks to the greater communication channels in the frequencies from 2 to 28 MHz to be able to use the existing power line installed to transfer the video surveillance cameras data also.

To remotely control the traffic counting system data, the weather station and the lighting system to the cloud supervision system, communication via SIM card is used on the telephone network. The communication network of the pilot can be divided into two categories: telephone communication network and powerline communication network.

Project co-financed by the European Regional Development Fund

Telephone communication is based on SIM cards on a 2G network (GPRS) to transfer data from the control panel concentrator to the cloud supervision system about lighting, the Weather station and vehicle counting system data.
The "General Packet Radio Service" (GPRS) is a mobile telephone technology that is organized to carry out a packet data transfer of a packet and a medium speed on a cellular network to connect to the Internet, using the TDMA channels of the GSM network.
The Weather Station is equipped with a battery that include a solar panel for charging and transfers the data to the panel concentrator via 868MHz wireless communication.
The powerline communication network uses two distinct technologies even though both use the same physical transport support and, specifically, the same power supply line as the lamps:

- the first is a 111KHz "narrowband" Powerline communication according to CENELEC standards in Band B with "ASK" type modulation to transfer lamp data to the control panel concentrator.
- the second is a "Broadband" Powerline communication with frequencies from 2 to 28 MHz, according to IEE 802.3u, Home Plug AV, OFDM modulation to transfer the camera data to the electrical panel.

3.5 Operational Plan

In the Operational Plan was explicated the implementation steps, pilot goals and requirements, predicting each component for the future implementation phase and their quantities.

Referring to the Operational Plan, initial system is designed to contain following components and quantities:

Table 3.1: Operational Plan, Bill of Material

No.	***System Component***	***Number of components***
1	LED street lamps with Controller and Lamp control device	20
2	Electrical Control Panel that feeds the lighting lines, with Control device and Cabinet command	1
3	system of 2 CCTV cameras with PowerLine transmission that allows to transfer Video signal of a camera using directly the 230vac Power supply line of the public lighting system	1
4	wave remote control system with sensors for the detection of traffic flows	1
5	Supervision Unit with device for measuring the electrical and energy parameters of the public lighting panel and with broadband powerline modem for transferring images to cameras up to the electrical panel	1

Project co-financed by the European Regional Development Fund

Technical requirements for each component ensure scalability, interoperability and maximize the performance and effects for smart city services, not only for the Smart Public Lights, increasing the efficiency and functionality of street lighting, expanding the street lighting system by adding additional functions and providing a platform for future smart city applications.

The Operational Plan for the smart public light system implementation define a few phases:

1) **Phase 1.** Implementation of redevelopment of the IP [QE 01, Lungomare Matteotti] plant by replacing 20 existing street lighting fixtures with new LED lighting fixtures with integrated powerline light point remote control device;
2) **Phase 2.** Installation of public lighting panel with integrated remote control devices;
3) **Phase 3.** Weather station installation;
4) **Phase 4.** Installation of the traffic counting system;
5) **Phase 5.** Installation of cameras with local recording and with integrated communication system directed to the Electrical Cabinet;
6) **Phase 6.** Commissioning of installed technological systems.

3.6 On-Site Implementation

The Esmartcity project, with the implementation of the pilot of "Viale della Riviera", constitutes the fundamental basis on which the Abruzzo Region and the Municipality of Pescara intend to carry out an innovative and energy redevelopment plan for the public lighting systems: the pilot proposes itself, in fact, as a precursor of the aforementioned innovative path.

As mentioned, the ESMARTCITY Pilot is located in Viale della Riviera, the waterfront of the Municipality of Pescara. The area of intervention of the project falls on the IP plants in the northern waterfront area - EP001 (one of the 280 plants of the City of Pescara). The complete control of the functionality of the public lighting electric panel is implemented, the system switch-on and switch-off times are optimized and all the electrical parameters of the plant can be checked. Thanks to the use of Powerline communication technology (Convoyed Waves) it is above all possible to transfer different types of digital information to the existing electricity network. Information on the functionality of the new LED lamps is retrieved and it is possible to send dedicated commands to the individual lamps to implement savings scenarios and optimize consumption. All without further wiring and using the existing electricity network used to power the street lights.

In addition to lighting control, other types of services and solutions have also been proposed:

- a vehicle counting system (able to classify up to 3 different vehicle categories)

Project co-financed by the European Regional Development Fund

- a meteorological station (with data on temperature, humidity, wind speed, solar radiation, UV rays ...)
- two video surveillance cameras with local recording on SD card and with image transfer on the electric network through powerline technology in this case with broadband.

The components that make the system smart in ESMARTCITY project are provided by UMPI (company specializing in the design and implementation of smart cities and smart lighting Solutions), and installed by ENELSOLE (Italian company operating in the public lighting sector for maintenance and management), that are Global Service for management and maintenance of public lighting system in Pescara.

Table 3.2: Implementation Report, Bill of Material for ESMARTCITY Project

No.	***System Component***	***Number of components***
1	LED street lamps with Controller and Lamp control device	20
2	Electrical Control Panel that feeds the lighting lines, with Control device and Cabinet command	1
3	Supervision Unit with device for measuring the electrical and energy parameters of the public lighting panel and with broadband powerline modem for transferring images to cameras up to the electrical panels	1
4	wave remote control system with sensors for the detection of traffic flows	1
5	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

The smart system thus obtained is called “Minos-X System” by UMPI and is represented in Figure 3.2.

Project co-financed by the European Regional Development Fund

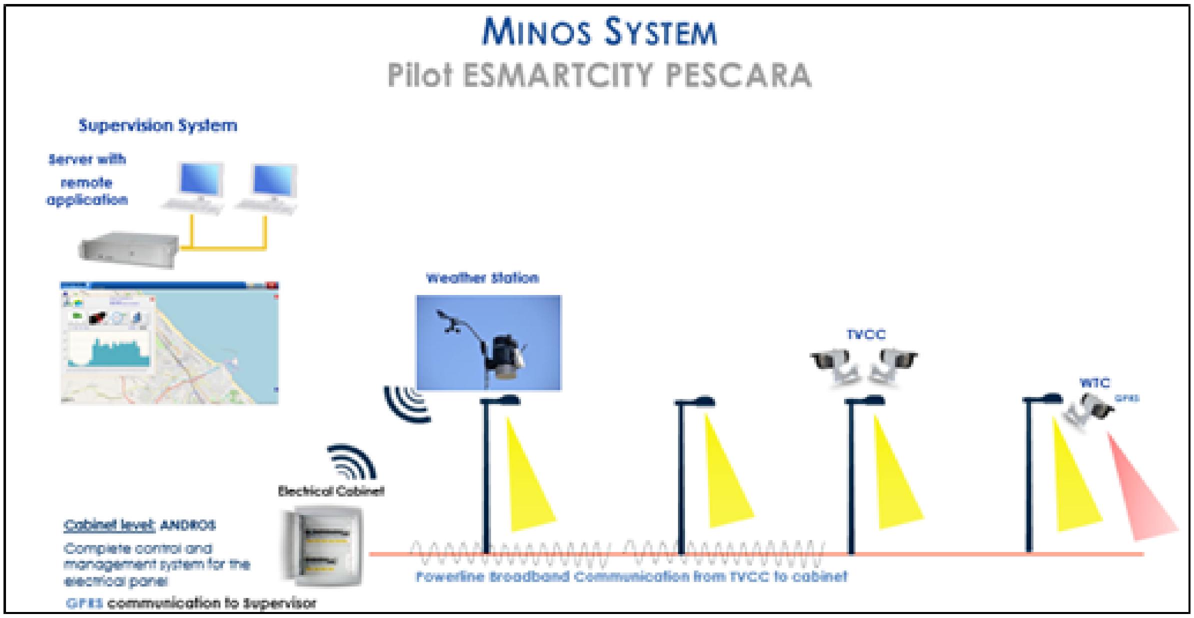


Figure 3.2: Minos System Scheme (Scheme of Esmartcity Pescara Pilot)

1. *Led Street lamps with controller*

The existing lighting fixtures (discharge lamps, glass cup, ferromagnetic ballasts, absence of remote control technology, low energy efficiency) have been replaced with new LED fixtures (4000°K, flat glass, in compliance with regional law on light pollution, equipped with point-to-point remote control, electronic ballast, high energy efficiency).

The Electric Panel (EP) has been equipped with a concentrator for the remote control system

Table 3.3: The equipment, typologies and consumption of new LED public lighting devices and old lamps

	Ante Operam	*Post Operam (As-Built)*
Equipments	20 lighting equipment 1 Electric Panel	20 LED Equipment 1 Electrical Panel
Equipment tipology	Street lights with glass cup equipped with SAP150/250W lamp (street lighting)	LED street lights ARCHILEDE HP BL56 42 LED 89 W 4000° K (street lighting)
Consuption	Absorded Energy: 49507 KWh/year	Absorded Energy: 18128 KWh/year

These new lighting LED fixtures are equipped with a controller lamp and control device, installed near the lamp at the top of the support. This controller allows monitoring all the parameters of each single light point such as: current, voltage, power factor, active power, lamp status, LED

Project co-financed by the European Regional Development Fund

temperature. The remote control device allows to control the switching on and off of the lamp and to adjust the luminous flux. This 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 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.

Figure 3.3: Lamp control module already installed

2. ***Electrical Control Panel that feeds the lighting lines, with Control device and Cabinet command***

Control cabinet controls all precedent lighting devices, made up of these components:

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 installed near the lamps (controller). 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 per panel.

Project co-financed by the European Regional Development Fund

Figure 3.4: Andros CMS-CPU MODULE

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 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).

Figure 3.5: Andros PLS - Power Line Module

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.

Figure 3.6: Andros TR - Power Supply Module

PAROS – MODEM GSM/GPRS

Project co-financed by the European Regional Development Fund

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.

Figure 3.7: Paros – Modem GSM/GPRS

3. ***Supervision Unit with device for measuring the electrical and energy parameters of the public lighting panel and with broadband***

The supervision unit is implemented with electrical parameters, panel-mounted remote control devices at the lighting framework level. These devices installed in the electrical panel has the following specific 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 mod-bus.

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

Project co-financed by the European Regional Development Fund

- 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 supervision unit is integrated with an external weather station, installed in one of lighting supports. This is a Wireless Plus station for the measurement of the meteorological parameters, solar and ultraviolet radiation. The weather station consists of an apparatus of external sensor for the detection of the parameters and from a central wireless receiver. Any parameter can later be transferred from the central unit weather remote display and supervision of lighting remote control system.

Technical characteristics of the devices in the Supervision Unit are reported in *Annex A.*

Technical characteristics of the weather station is reported in *Annex B.*

Therefore, the Control Cabinet installed on Pescara pilot is reported in the Figure 3.8, with integrations of the Supervision Unit. The figure contains all devices that are described in the Annexes below (non only devices described in the *Annex A)*, because some of external devices like video-surveillance cameras or traffic analysis system requires specific components to be installed in the cabinet. For greater clarity these components are reported in the Annexes of every specific external device.

Instead, in Figure 3.9 is reported the weather station installed in Pescara Pilot.

Project co-financed by the European Regional Development Fund

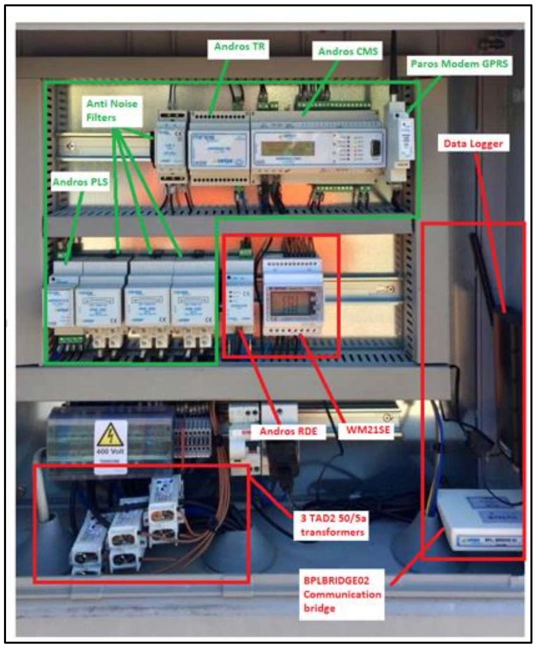


Figure 3.8: Control Cabinet of Pescara Pilot

Figure 3.9: Weather Station installed in Pescara pilot (airview on the left, bottom view on the right)

4. System of 2 CCTV cameras

The TVcc camera system 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.

Project co-financed by the European Regional Development Fund

The system consists of IP-type digital cameras, integrated with a special converter/modem on the PowerLine network. The device allows converting the video stream from a signal on an Ethernet network to a signal on a power line, to implement. 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.

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.

Technical characteristics are reported in Annex C. The figure below reports the installation in Pescara.

Figure 3.10: Video surveillance system installed in Pescara pilot

5. ***Wave remote control system with sensors for the detection of traffic flows***

Traffic analysis (enabled for TAI adaptive lighting) include sensors for the detection of traffic flows that are installed in a non-invasive way, without affecting the road surface. The sensors count the vehicles transiting in both directions (in and out on the line of installations), distinguishing 3 categories (motorcycles, car and 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 (Andros CMS), located inside the electrical panel: from this, then, the data

Project co-financed by the European Regional Development Fund

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.

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

Annex D reports technical characteristics of the Traffic Analysis device (TAI).

Figure 3.11: WTC installed in Pescara Pilot

3.7 Data Centers

Until 2017 the existing public lights system in the Pescara was a conventional old lighting system without ICT-driven solution present. It means that there was not any communication of information about current state of the system to the City public services management.

Then, in June 2017, Pescara Municipality activated a path of energy requalification and lighting of the city, in order to optimize energy consumption, improve the liveability of the city and implement a path of innovation in the public service. This allowed the city to make an innovative change (with a first activity of energy requalification of the public lighting system): all old lamps were replaced with new LED luminaires, which allowed to pass from an energy consumption of 14000 MWh to about 4000 MWh. In the pilot the reduction of energy consumption is from 49507 KWh/year to 18128 KWh/year. Another innovative implementation was the creation of a web portal where the citizen, who represents the end user of the improved service with the aforementioned efforts of the Municipality, can learn the data about the efficiency of such an innovative plant: everyone can, with user e password, access to this web portal and observe real-time data, such as energy consumption.

In this state of the art already innovative, the Abruzzo Region (through agreement with the Municipality of Pescara) has decided to invest economic resources in the study of the pilot case of Esmartcity, defining an area of the public lighting system and integrating it in a smart way. With the Esmartcity project the Abruzzo Region partner wants to demonstrate that the applicability of the aforementioned innovative technologies, following the path towards the complete affirmation of the Smart City concept, is essential in order to create a context of daily living ideal for the citizen. This pilot case, with its character of scalability and replicability, would like to be a stimulus to all the realities of the territory to invest in the Smart City technologies. In this way, the citizen could learn not only data not only from the already implemented EnelSole web real-time portal (about consumption and parameters on public lighting), but also data on everything that the aforementioned Smart system implemented can communicate (environmental parameters, anthropic influx on the pilot, state of natural lighting, state of artificial lighting deriving from the presence of vehicular traffic, consumption, etc.).

The new innovative system, which is implemented in Esmartcity project, is characterized by a data-driven self-regulation mode for switching on, switching off and adjusting the intensity of artificial light and by the monitoring and control of other parameters (video surveillance and car traffic): all this should deliver an optimal quality service to the citizen, increasing the efficiency of public service and improving the decision-making process with a data-driven support.

The system is connected in bidirectional communications mode with the data center(s) where the collected data is stored for the analysis and calculating optimal decision as a response on real needs in the real-time. That means that the data driven decision-making can deliver the maximal the Quality of Service and the Quality of Life for the citizens against the power consumption and environment degradation. This trade-off is possible by collecting the relevant group of parameters for deterministic mathematical-based computations.

Key data to be collected are: weather conditions, energy parameters, intensity of presence of pedestrians and traffic in the location (and so learning all the citizens habits in any time interval, improving public safety)

Project co-financed by the European Regional Development Fund

In the case of a Pescara, there is the official data[1] about existing public light nodes for the whole municipality:

- number of public light nodes: 22000
- energy consumption per year (with old Lamps): 14000 MWh
- energy consumption per year (with new LED Lamps): 4000 MWh
- energy costs per year: 30,00 € for person [2]
- saving with innovative system (led and smart devices): 50%

For the pilot project chosen a location - stretch of about 400 meters of Viale Primo Vere Road - there is a specific data about the energy consumption ante-operam, with old sodium lighting lamps (ante 2007) for the QE01 (area of Esmartcity pilot). The result post-operam is reported below, based on technical data and specifics of the new lighting system.

Table 3.4: Electrical Data Ante Operam

ANTE OPERAM			
Device	Quantity	Unitary Power [W]	Total Power [kW]
Arm. Str. SAP 150W	25	175	4,59
Arm. Str. SAP 250W	25	280	7,35
Incassi 70W	10	78	0,82
Segnapasso 3W	95	3	0,30
Proiettori - 250W	1	280	0,29
Arredi - 150W	2	175	0,37
	158		**13,72**

Table 3.5: Electrical Data Post Operam

POST OPERAM			
Device	Quantity	Unitary Power [W]	Total Power[kW]
Arm. Str. LED 62W	25	62	1,63
Arm. Str. LED 89W	25	89	2,34
Incassi 70W	10	78	0,82
Segnapasso 3W	95	3	0,30
Proiettori - 250W	1	280	0,29
Arredi - 150W	2	175	0,37
	158		**5,74**

From tables above, it is possible estimate the business model that involves in financial effects for energy savings, considering an average power on time in a day (13 hours).

[1]Source: http://www.pescarapost.it/economia/pescara-gas-nuova-denominazione-pescara-energia/51272/
[2]Source: http://www.ilcentro.it/pescara/ecco-quanto-costa-illuminare-i-comuni-1.1482834

Project co-financed by the European Regional Development Fund

Table 3.6: Energy and Costs average savings

Light Source Type	Total Power [kW] (Consumption)	Cost/kWh [€/h]	Consumption/year [kW]	Costs/year [€]
Ante Operam				
Na	13,72	0,07 €	65101,4	4.557,10 €
Post-Operam (Savings using Smart Monitoring)				
LED	5,74	0,07 €	27236,3	1.906,54 €
Total Savings				**2.650,56 €** **58,16%**

The table below shows that, with an innovative and efficient system consisting of a lighting system that is efficient and upgraded with a smart system, allows to optimize consumption, and therefore costs, by calibrating the switching on of the devices according to the environmental parameters and the anthropic crowding. Cost savings, therefore, is around 50%.

The Data reported about energy consumption in Figure 3.8, based on technical data of the devices, is very close to the data measured by the electrical panel, reported in the image below (taken form software monitoring system that will be described in the next paragraph). In fact, it is denoted as the data estimated by technical sheets (5.74 kW) and that monitored by the system (5.76 kW), implies a negligible difference of 0.02 kW).

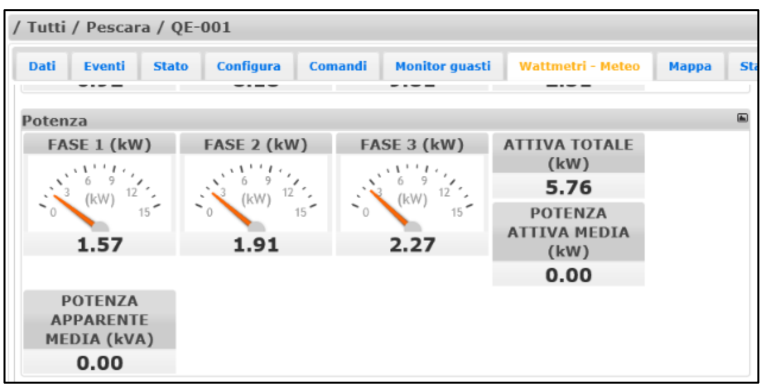


Figure 3.12: Energy consumptions taken from software monitoring platform of smart system

The software analyze and collect data updating retrieving environmental benefits for the current state of energy saving and the total saving for the period from installation until now.

Beside primary economic and power benefits, there are many secondary and tertiary benefits of the Smart Public Lighting System implementation. The collected data is useful to contribute, in the future, to an Open Data system which allows citizens to connect and get support for their daily lives.

Project co-financed by the European Regional Development Fund

3.8 System Management, Data Collection and Analytics

The system of smart lightings in Pescara has 1 data center, that is located in EnelSole structures, the global-service for maintenance and management of all the public lighting systems in Pescara. This one has several functions, management control and collected data in the real time about public lighting system. The system provide an overview about the public lighting system, statistics, trends, for the current optimization, creating an automatic decision making, with the public retrieving possibility.

The result is a public lighting system with updated electrical panels and cabinets for remote control and renewed lighting components, in the view to improving energy efficiency. All the system is implemented with a Web Platform (with user and password) where the manager can acquire statistics on the lighting situation, on the consumption situation, and have support on decision-making.

Therefore for the electrical cabinet of the pilot (QE01) the web monitoring and analyzing data platform is been implemented with new data from smart sensors, except for Traffic Analysis (a different platform exclusively dedicated to counting cars and vehicles in the point of WTC installation, with a series of algorithms to extrapolate data) and video-surveillance, that had requested a new Data Center and a new Web Platform (provided by the supplier of new smart devices). Therefore, the result of Esmartcity project in management, collection and analysis system terms, is a total web control platform where the operator can improve automatic making-decision modalities, observe the situation in real time, and collect data.

The main screen of the Web Platform is represented in the figure below: from here it is possible to access to every information, as current level of energy consumption, electrical data, weather data (temperature, pressure, wind data, rain data), traffic analysis or video-surveillance; there is also the possibility to have historic series of every kind of data.

Project co-financed by the European Regional Development Fund

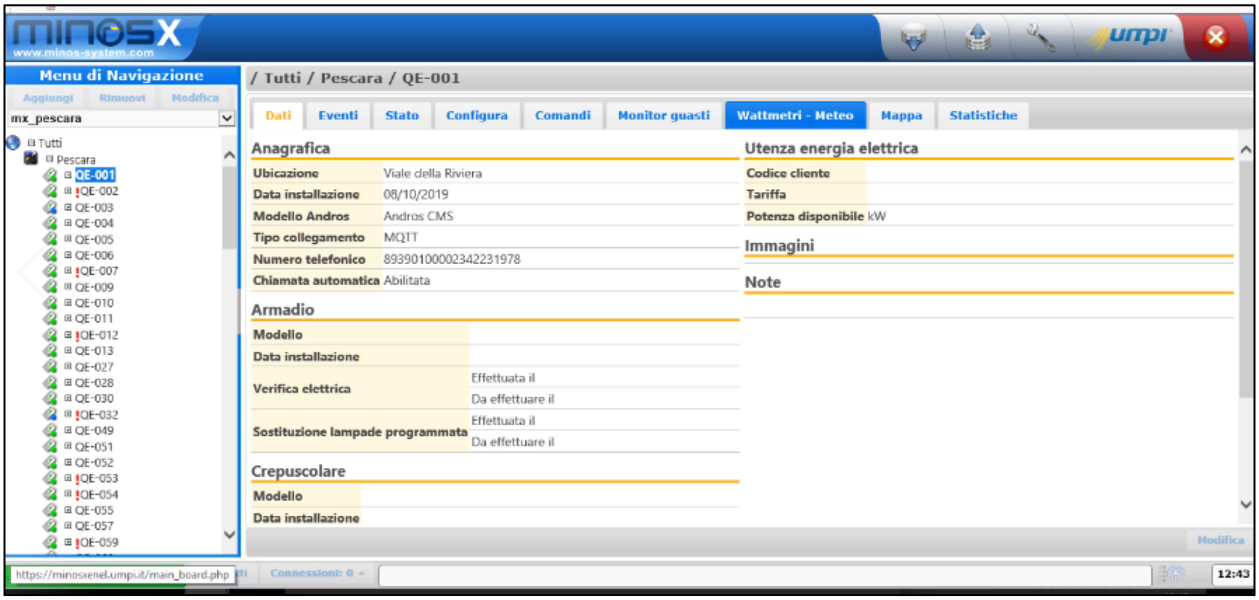


Figure 3.13: General data on the Cabinet QE01

Another additional option in Web Platform is geographical overview of all cabinets of public lighting system in Pescara city: the Esmartcity project, as aforementioned, is on QE01 (EP001).

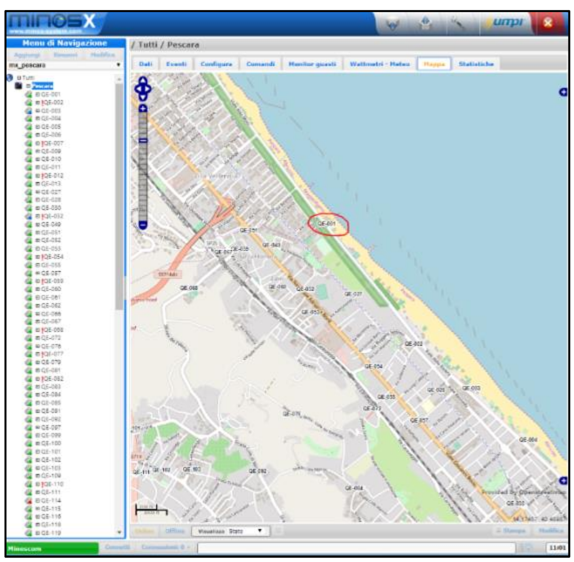


Figure 3.14: All cabinets Map - QE01 circled in red

In the figure below there is an example of monitored data.

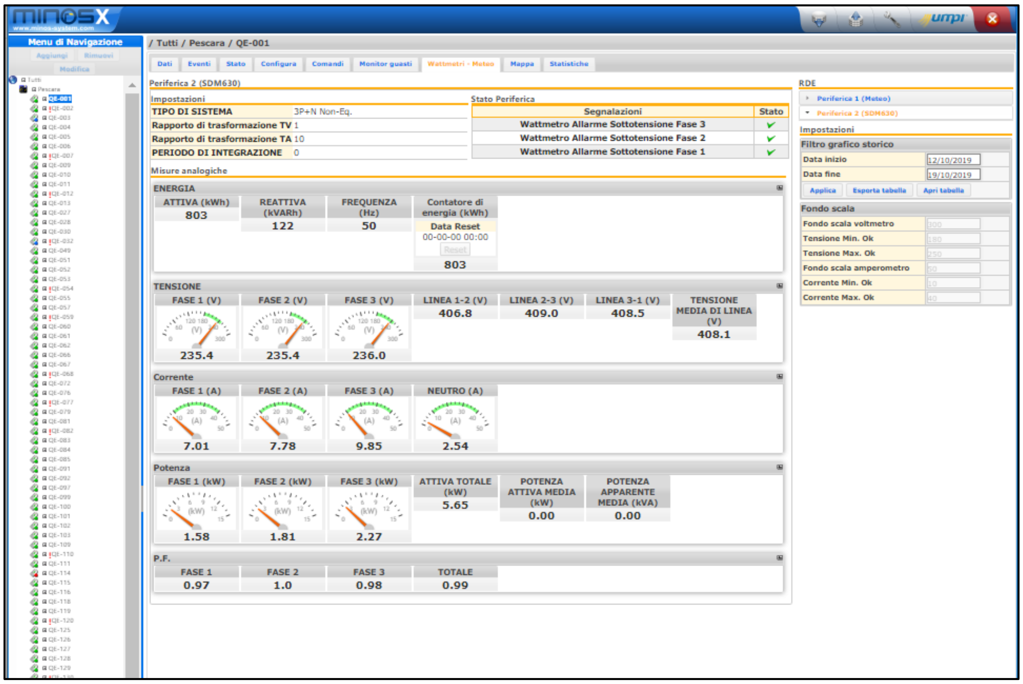


Figure 3.15: Energy, electric and power data on the cabinet with the possibility to export Data

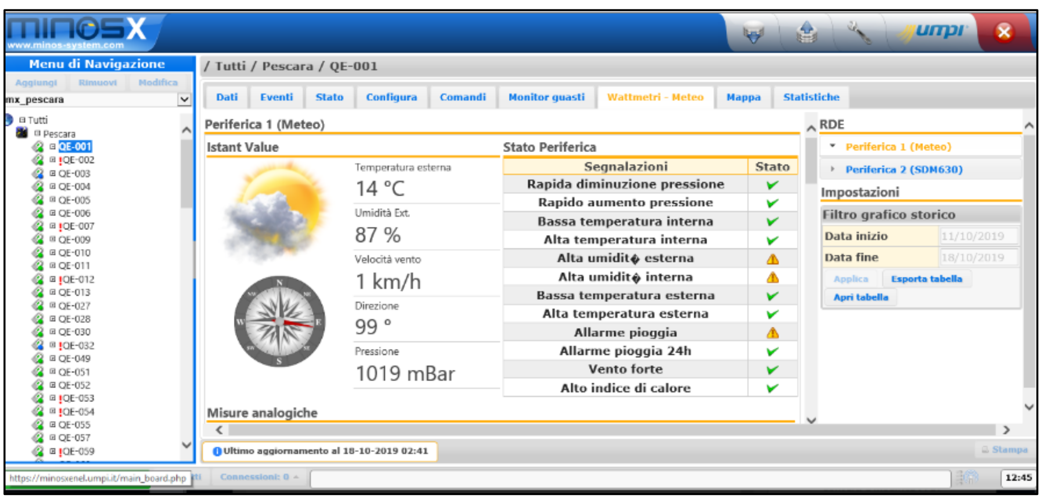


Figure 3.16: Weather Parameters on QE01 (temperature, wind data, pressure)

Project co-financed by the European Regional Development Fund

Figure 3.17: Video-surveillance

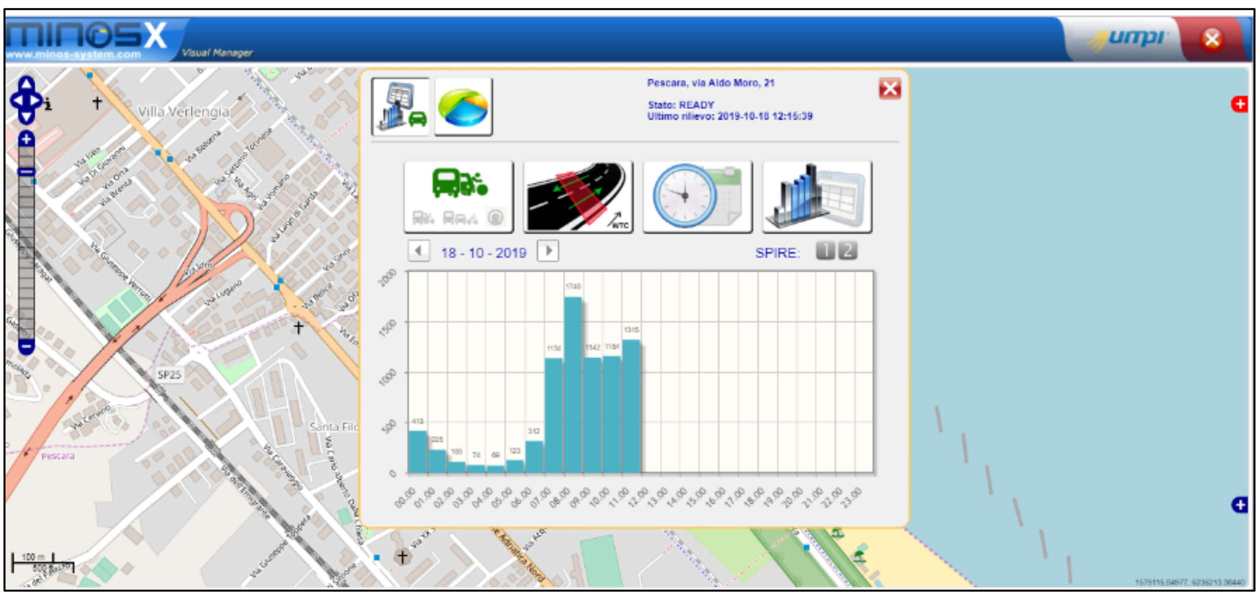


Figure 3.18: Traffic Analysis Dashboard

A more specific technical description of this Web Platform is reported in *Annex E*.

Project co-financed by the European
Regional Development Fund

4 Conclusion

The project was proposed to achieve sustainable goals in energy saving. The main objective was to create an innovative pilot case that could build the starting point for future development, raising public administrations and SMEs to use smart technologies. In fact, after the implementation of the pilot case and after the funding period, a commitment by the public administrations is essential both in the management and regulation of smart technologies, but also in the development of the same to cover new areas of the city.

It shows how, with innovative application as the proposed one, there are positive effects in energy saving, but also in the safety of the city and, more generally, in the quality of the service offered to the citizen. In fact, such an application demonstrates **a halving of consumption** in the first place, but also it defines the way to go in the future for the realization of smart cities that satisfy all possible needs.

In particular, the Esmartcity project, with the implementation of the pilot of "Viale della Riviera", constitutes the fundamental basis on which the Abruzzo Region and the Municipality of Pescara intend to carry out an innovative and energy redevelopment plan for the public lighting systems: the pilot proposes itself, in fact, as a precursor of the aforementioned innovative path. With this Pilot, Pescara Municipality and Abruzzo Region aims to show all the benefits of a such innovative project, that allows to improve quality life in the modern cities: Pescara Municipality has developing a larger technological and smarter innovation plan of the city managed by Enel Sole as Global Service, where all public lighting will become more efficient within June 2020.

This approach includes all the stakeholders of a community, including governments, civil society and industry, following the Open Innovation 2.0 model approach.

Project co-financed by the European Regional Development Fund

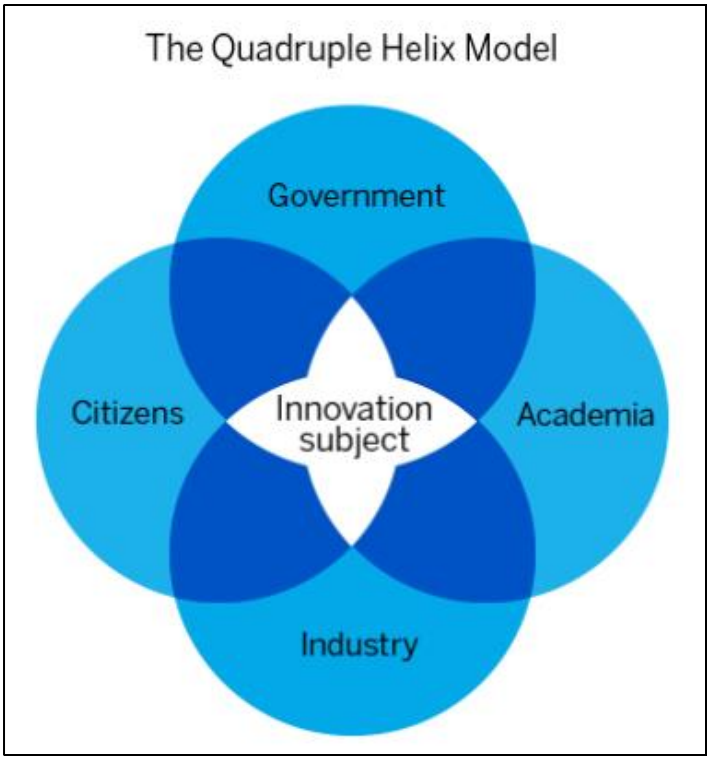


Figure 4.1: Quadruple Helix Open Innovation model 2.0 (10)

The Urban Growth involves many challenges to plan infrastructure that are able to serve all needs of citizens: these challenges are linked with increasing the number of city inhabitants and physical expansion of cities.

Different studies regards Smart Cities, but the way is to assemble a one model. Without cohesion, the smart city concept is not exploited to the full. The longevity of a smart city have to be based on an holistic vision that provides a common understanding among smart cities stakeholders. The correct way is ensures projects and ecosystems with proper foundations that are economically and socially sustainable. This holistic vision is essential to emphasize the importance of assembling technology, governance and strategic factors to be able to build a smart city and innovate in cities across Europe with different ecosystem partners. (11)

On a wider view, the project is affecting many other challenges too, as safety and security, biodiversity, transportation, and the Quality-of-Life as a whole.

4.1 Climate, Environment, Air Quality Effects

Growth like that described in cities can cause climate change. Therefore, in view of energy savings and Green Growth directives, one of the main challenges for governments is to share the use of energy, optimizing its uses. Therefore it is clear that services must be offered by optimizing the

Project co-financed by the European Regional Development Fund

distribution of Energy and Water, ensuring satisfactory development in infrastructures and waste management, with a view to having sustainable megacities.

4.2 City Management Optimization

This project aims to be an example to increase the efficiency of energy management in the city. Such an approach can motivate local governments to invest in the use of smart infrastructures. This approach is reflected in an optimization of public spending, thus being able to invest that public money saved in other activities at the service of citizenship (green areas, schools, infrastructures, etc.) increasing the life quality.

4.3 New Business Opportunities

As previously mentioned (Open Innovation model 2.0), such an approach also involves the corporate world. In fact, the new challenges in smart cities motivate SMEs and the entire market to invest in new smart solutions with low energy consumption. This allows that the local government can create many sideline projects in the Public-Private Partnership involving the (local) industry and the business sector into the process of the City development.

Moreover, a new urbanization and the need for a smart and interconnected city allowed, for example, to raise some cities, such as Brussels or Seoul, to be more important than the country itself as they contribute with over 30% to the national GDP according to the OECD . In other cases, the same governments, see UK, are equipping themselves with a Ministry for the Cities that we have a specific focus on them. All of this involves various business scenarios. (12) Applications such as infrastructure and charging services for electric vehicles (EV), intelligent street lighting, intelligent buildings, distributed energy resources (DER) and smart city communication networks all offer new and significant business opportunities. In conclusion, the process of growth and creation of smart cities predicts, on average, a growth of the sector from the current 36 billion Euro to 87 by 2026. Other estimates of important market analysts argue that the market could be worth 1,401 billion euros already in 2020. (12)

4.4 Civil Society Involvement

The project is based on engaging of inhabitants in many ways. The first one is the reduction of light pollution, in observance of their habits: is important to learn these about public questionnaire, to engage them requested parameters of quality life. Since technology cannot work alone, lack of communication with citizens results in top-down approaches. So projects have to be developed with input from civil society, taking into account its culture and customs.

Project co-financed by the European Regional Development Fund

4.5 Innovative Solutions

The innovative character of the project is given not only by the use of smart sensors and technologies, but also by the involvement of technologies linked to parallel opportunities.

First, the main opportunity is linked to the analysis of data and Open Data applications: this entails, for the purposes of automatic operation of lighting systems, Machine Learning and Artificial Intelligence applications, which represent another innovative element. Other innovative aspects are those of new business opportunities (previously mentioned) that can be developed starting from a pilot like the one in question; these are infrastructure and charging services for electric vehicles (EV), intelligent street lighting, intelligent buildings, distributed energy resources (DER) and smart city communication networks all offer new and significant business opportunities.

Another innovative step that can be achieved in the future in a smart city is that of monitoring the safety of existing public infrastructures (a topic of considerable importance in Italy today). We talk about Structural Health Monitoring, or the structural monitoring of infrastructures (such as bridges and viaducts) that in Italy are beginning to be a heritage that needs more attention (see the recent news stories, such as the collapse of the “Polcevera” bridge in Genoa in the 2018). S.H.M. is a process that identifies the structural damage by means of a network of sensors connected to a data acquisition unit, via cable (wired) or with wireless (wireless) technologies. This process involves the observation of the structure or of a mechanical system over time using periodic static or dynamic response measures distributed over time, the subsequent extraction of the characteristics or parameters correlated with the analyzed damage and the statistical analysis of these, in order to determine the status of the examined structure. An innovative application is the use of optical fiber used not as a means of communication but as a sensor: it, made integral with the structure to be monitored, may indicate structural damage correlating this to the variation of the transmission of its signal. (13)

Project co-financed by the European Regional Development Fund

5 Future Work

The aims of Pescara municipality with Esmartcity pilot are:

- 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
- Contribute to providing policy makers, PA and energy managers with decision support tools to optimize environmental impacts of their decisions and operations.

These aims are defined according to Application Form. There are two challenges, that define future works. They are testing challenges as:

- increasing the level of innovation in MED cities by enriching city infrastructure via smart devices, embedded systems and sensor/actuators, and deployment on top of this of innovative applications/services creating missing end-user pull for highly innovative SC sub theme;
- enhancing innovation potential of SMEs in the area networked by the project in the Smart City MED community and participating in Capacity Building interventions allowing them to utilize Smart City infrastructure as test bed for innovative applications/services.

In these view, a first step of future work is a correct assessing of the pilot, monitoring all the principle parameters (as defined in the Esmartcity works) and demonstrate the social and economical utility of similar activity like Abruzzo Region Activity. This phase of evaluation of results involve, as written before, the inhabitants of the City with questionnaire, in order to make the project and its realization functional to the request of the end user, or citizenship.

Then, with this Pilot, Pescara Municipality and Abruzzo Region aims to show all the benefits of a such innovative implementation: this allow to envelope a larger technological and smarter innovation plan of the city managed, as is happening in Pescara, with an innovative program where all public lighting will become more efficient within June 2020.

5.1 Existing Resources Usage Optimization

The Esmartcity project in Pescara is part of an already organized energy redevelopment activity. With this pilot project, the Abruzzo Region wants to demonstrate how, by combining smart services with technologies that are already functional to energy saving (remote controlled LED systems), savings are achieved in terms of energy and costs. Indeed, with a view to obtain an automatic functioning of the system, the monitoring through sensors of various parameters (flow of people, natural light, etc.) is used to further minimize consumption and pollution in urban

Project co-financed by the European Regional Development Fund

areas. These economic savings as a result of energy savings allow municipalities to invest in other activities (eg waste management and green area construction and maintenance).

5.2 Green ICT-Driven Solutions and Sustainable City of Pescara

The issue of climate change closely concerns urban areas, where around 80% of the energy consumed in the entire European Union is used. The common goal throughout the union is the reduction of carbonic anhydride: the Covenant of Mayors, with 9837 signatures for totally 314971,482 inhabitants, aims to reduce emissions by 40%. In a lighting public system, the first step is the substitution of old lamps with LED devices: this activity started in Pescara and Esmartcity is the basis for the development of these activities.

5.3 Reduction of Light Pollution and Preservation of Biodiversity

An automated system that learns from the habits of the place is functional not only for energy savings, but also for the reduction of lighting pollution and the preservation of biodiversity. In fact, a smart system must also take into account that, in compliance with regional laws in lighting pollution, too high artificial light can cause problems. Therefore, monitoring the presence of people and vehicles near the plant is of vital importance: the goal is to reach the right compromise between light and dark. Finally, the abuse of artificial light could compromise the existence of some types of plants and animals, influencing their life cycles.

5.4 Safety and Security

On the basis of the pilot implemented, new activities can be started concerning the health and safety of the population. For example, a possible future job in the city of Pescara could be to equip each city gate with a WTC like the one in the pilot. In this way, the quality of the traffic could be improved, through an adaptive operation, for example, of traffic lights, or favor the adaptation of signs and obligatory directions according to the habits of the citizen.

5.5 An Attractive City with Comfort and Quality of Life

The intervention in question is part of an innovative city concept that implements an improvement in the quality of life. For example, possible future implications could be those of the complete switchover to electric vehicles in Italy, the creation of a network of charging stations or even come to innovative applications such as the use of asphalts that recharge electric vehicles in gear (realities already present in European Union cities like Oslo).

Another future service that could be present in a smart city is the lighting of paths and roads with certain colors, depending on the traffic conditions.

Project co-financed by the European
Regional Development Fund

5.6 Maximum Experience and City Marketing

Energy efficient lighting must also consider the need to highlight some places rather than others (monuments, places of public crowding like stadiums, or places subject to marketing). All this maximizes the experience of visitors and residents.

5.7 The Potential Integration with Future Co-Existing Smart Services based on The Pilot

It is necessary to underline how the pilot under examination, using the described Powerline technology, already allows the co-use of the electric network for the transport of the monitored data to the electrical panel.

However, the pilot presents several co-located services with light system. For example, the system can become an integral part of a Smart Grid, enabling the integration of distributed energy resources in the urban network, enabling interdependence and facilitating a multi-services approach linking the electricity carrier and other infrastructure.

Project co-financed by the European Regional Development Fund

6 Annex A

Technical characteristics of devices in Supervision Unit

Devices for measuring the electrical and energy parameters implemented in the supervision unit are:

a. *1 Andros RDE (Cod. 61923)*, Event Recorder Module for registration of electrical parameters of network analyzer modules (Up to 15 connected network analyzer modules, Dimensions 35.5x90x75 mm, 2 DIN modules)
b. *1 WM21SE (Cod. 62175NE)*, Network analyzer for reading electrical parameters and energy count for three-phase line.
c. *3 TAD2 50/5A (Cod. 40148)*, Class-wire current transformer 3 1VA, diam. hole 23 mm. 50A/5A version

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.

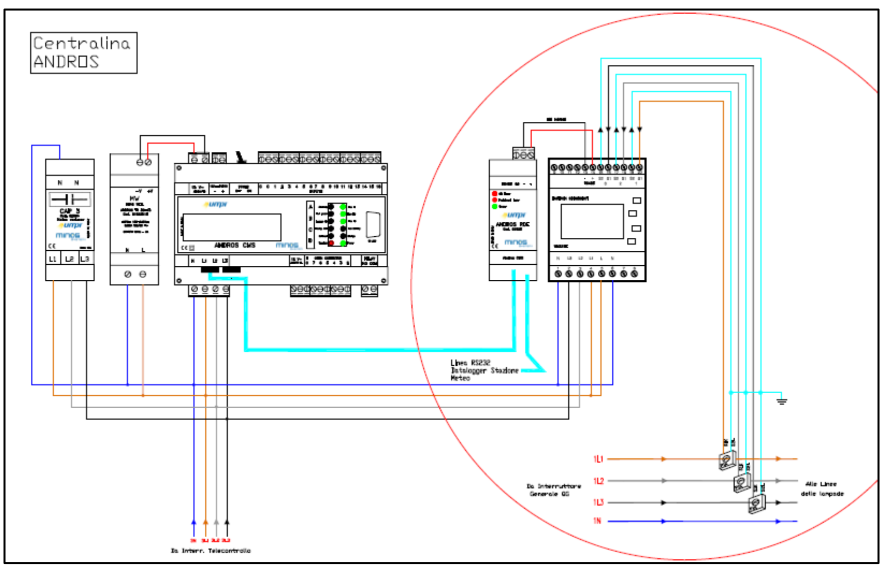


Figure 6.1: Remote control scheme with Esmartcity (in the red circle)

Therefore, the new smart component mentioned above and installed in Control Cabinet are:

a) Andros RDE

Andros RDE is an Event Recorder Module for registration of electrical parameters of network analyzer modules, directly connected to ANDROS CM. This data acquisition module collects

Project co-financed by the European Regional Development Fund

measurements made by peripheral devices such as wattmeters, weather stations or other measurement and acquisition devices. The device represents an accessory module, in the composition of the ANDROS station (ANDROS CMS), which is required when the request is to acquire and check the electrical measurements of particular three-phase lines, and/or the measurements of control units weather. ANDROS RDE performs the functions of an event recorder module, it can simultaneously manage up to 16 peripheral devices connected via RS485 bus (for each device there is a memory bank for the data recording). It samples the data provided by peripheral devices every minute and can store a sample every minute or every 15 minutes (optional configuration via software). Furthermore, it is possible, by means of a server, to set the recordings only when the system is on, avoiding recording the measurements when the system is off. Totally in ANDROS module RDE can control:

- 1 weather station
- N. 15 network analyzers mod. WM14; WM3, KEA (N.B .: 16 devices if the Meteo control panel is not present)

Table 6.1: Event Recorder Module characteristics

Event Recorder Module (Andros RDE)	Quantity
▪ Memory: 16 RAM Bank (32 kB, one for every peripheral device) ▪ Sampling: 1 minute ▪ Data Storage from Sampling: every minute or in 15 minutes' interval ▪ Link with peripheral device type: bus RS485 and/or RS232 ▪ Communication speed: 9600 bps ▪ Link with command and control module (Andros CMS): 8-pole cable RJ45 ▪ Input Voltage: 5Vdc +/- 10% ▪ Current: 50 mA @ 5Vdc ▪ Absorbed power: 20VA ▪ Operating temperature: -20°C - +60°C ▪ Dimensions: 35,5 x 90 x 75 mm – 2 din modules ▪ Weight: 85g ▪ Electrical insulation rating: Class III ▪ Housing: IP20	1

Project co-financed by the European Regional Development Fund

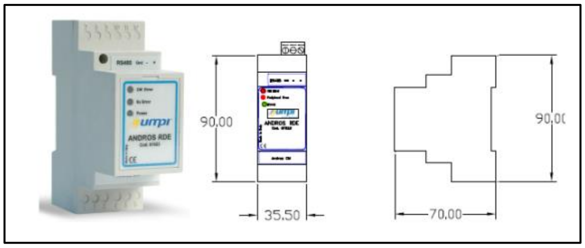


Figure 6.2: Andros RDE

Andros RDE is connected to Andros CMS with a8-pole cable RJ45 and with peripheral devices with bus RS485 or port RS232.

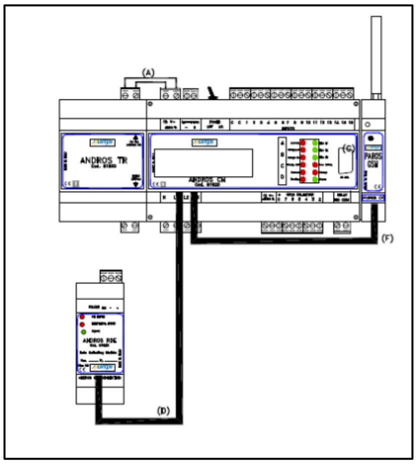


Figure 6.3: Connection Andros CMS-Andros RDE

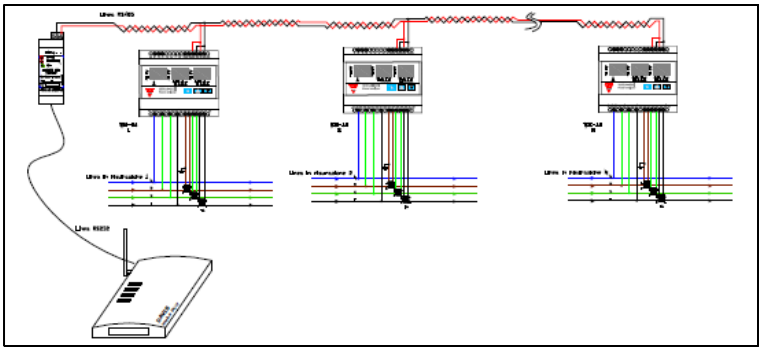


Figure 6.4: Connection Andros RDE-peripheral devices

Project co-financed by the European Regional Development Fund

b) WM21SE

WM21SE is a network analyzer for reading electrical parameters and energy count for three-phase line. It WM21 can be selected as positive active energy counter and some minor parameters, or as positive active and reactive energy counter and some minor parameters or as display of all electrical quantities. It is a din rail meter for single and three phase electrical system. WM21SE measures and displays the characteristics of single phase two wires(1p2w),three phase three wires(3p3w) and three phase four wires(3p4w) networks. The me asuring parameters include voltage(V), frequency(Hz),current(A),power(kW/Kva/Kvar) ,import, export and total Energy(kWh/kvArh).The unit can also measures Maximum demand current and power, this is measured over preset periods of up to 60 minutes. This unit is a 1A or 5A current transformer operated and can be configured to work with a wide range of CTs. Built-in pulse and Modbus or M-Bus outputs. Configuration is password protected. This unit can be powered from a separate auxiliary (AC or DC) supply. Alternatively it can be powered from the monitored.

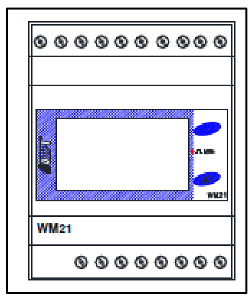


Figure 6.5: WM21SE

The connection with Andros RDE is with RS485 bus.

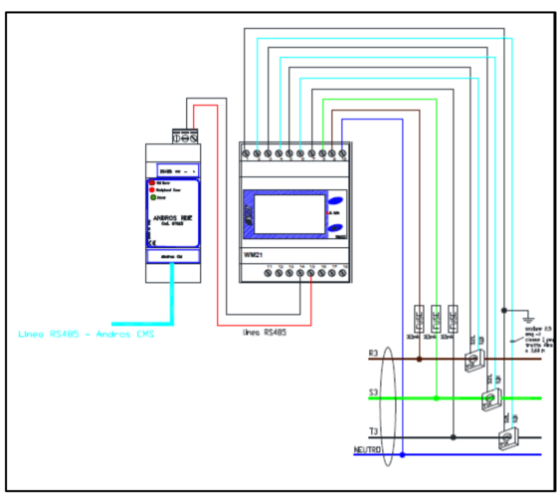


Figure 6.6: Connection with Andros RDE

Project co-financed by the European Regional Development Fund

7 Annex B

Weather Station that integrates electrical parameters in Supervision Unit

The Wireless Plus station for the measurement of the meteorological parameters, solar and ultraviolet radiation METEO2 Station (Cod.61845): the device includes software module for integration on Minos-X platform. The weather station consists of an apparatus of external sensor for the detection of the parameters and from a central wireless receiver. Any parameter can later be transferred from the central unit weather remote display and supervision of lighting remote control system, through a connection with the appropriate acquisition device (Andros RDE, Cfr. Annex A). The external weather detection station is supplied in wireless version and is equipped with a cell solar powered and battery Lithium and integrated sensor block.Inside the integrated sensor block (ISS) there are:

- Rain gauge: for detecting rain quantity (in mm or inches)
- Anemometer: for wind speed and direction
- Outdoor temperature sensor
- External humidity sensor
- Solar radiation sensor
- Ultraviolet radiation sensor
- Integrated block for containing sensors
- Solar power cell
- Wireless transmission module
- Wireless data reception console
- Internal temperature and humidity probe

Table 7.1: Weather Station characteristics

Weather Station (Wireless Plus Station Meteo2)	Quantity
▪ Link: modular RJ11 ▪ Input Voltage: 5Vdc ▪ Battery: 3 A-A cells, duration 4 months ▪ Current: 200 mA @ 5Vdc ▪ Wireless Frequency: 968.0-969.6 MHz FHSS ▪ Operating temperature: -18°C - +60°C ▪ Dimensions: 165 x 95 x 38 mm ▪ Weight: 260g ▪ Internal temperature sensor: 0°C- +60°C, +/-1°C, update 1 min ▪ Barometric pressure sensor: +800a - +1080.0 hPA/mb, installation from -460m to 4670m, update 1 min ▪ Relative internal humidity sensor: range from 10° at 90% RH, +/-5%	1

Project co-financed by the European Regional Development Fund

Figure 7.1: Weather Station Meteo2

Project co-financed by the European
Regional Development Fund

8 Annex C

System of 2 CCTV cameras

The 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. The 2 video cameras and broadband conveyed wave system includes:

a. *4 BPLBRIDGE02 (Cod. 61008)* Communication bridge on the electrical network (Broadband on Power Line = Smart PL) AVEthernet,200Mbps
b. *2 Phil 2.5CX (Cod. 62048)*, Powerline interference suppression filter in series with electric loads, for currents up to 2.5A
c. *B-FIXEXT-HI+SD Card 128G (Cod.83001BH1+69055-128)* IP Color Camera Resolution 2Mp @ 1080P, 2.7 "CMOS sensor, Color, varifocal lens 3.3-12 mm F1.4. IDnr; Day / night; streaming quad H. 264; cloud services; ROI; detection movement / tampering / audio; 1080p. *BOSCH TYPE NBN-50022-V3*. Complete with 128GB SDXC card (code,power supply (POE or external) enclosure from external with internal thermostat and bracket pole anchorage. Configuration included

a) 4 BPLBRIDGE02

The BPLBRIDGE02 is a Communication bridge on the electrical network (Broadband on Power Line = Smart PL) AVEthernet. It is used to transmit an Ethernet signal on PowerLine network, with max 200Mbps speed.

Figure 8.1: BPL Bridge 02

Table 8.1: BPL Bridge 02

BPL Bridge 02	Quantity
▪ Alimentation: 100-240Vac 50-60Hz ▪ Absorbed current: 0,2A ▪ Working temperature: 0°C, +40°C ▪ Relative Humidity: <90% ▪ Ports: 1 Ethernet 10/100 Mps, Auto-Sensing, Auto-Crossover RJ45 ▪ Dimensions: 115x30x76mm ▪ Weight: 135g	4

Project co-financed by the European Regional Development Fund

▪ Standard: IEE802.3u, Home Plug Av ▪ Max speed: 200 Mbps	

b) B-FIXEXT-HI+SD Card 128G

Is an IP Color Camera Resolution 2Mp @ 1080P, 2.7, model BOSCH NBN-50022-V3. It include with 128GB SDXC card (code, power supply (POE or external) enclosure from external with internal thermostat and bracket pole anchorage.

Figure 8.2: Dinion IP 5000 HD

It is a video surveillance system on-line, provided with a compact and elegant housing. The camera is provided with a sensor CMOS HD 1 / 2,7”, and it is a True Day/Night camera that allow to obtain a good performance both day and night. It is a content-based imaging technology (C-BIT) and it is used to radically improve quality of images in all light conditions and identify advanced processing areas. The camera analyzes the scene using video analysis intelligent and provides directions to adjust image processing again. In this so better quality of details are provided in areas of relevance and overall performance excellent. The camera uses intelligent Dynamic technology Noise Reduction (iDNR), which performs an active analysis of the contents of a scene, consequently reducing disorders, noises and imperfections. The low level of image disturbances and the efficient “H.264” compression technology provide scenes sharp and reduce bandwidth and requirements by up to 50% storage compared to other H.264 cameras. In that way, the streams have bandwidth minor while still maintaining a quality high image and smooth movements. The areas of interest (ROI) can be defined user. The E-PTZ controls remotely allow you to select specific areas of the main image. These zones produce separate flows for the remote viewing and recording. These flows, together with the main one, allow the operator to monitor the most part separately interesting of a scene and keep a vision overall at the same time. The camera is provided with microphone that allows to operators to monitoring the audio in the monitored zone. Furthermore the 2-lines audio allows to the operator to communicate with visitors or intruders, and a system of movements detection or manumission is integrated. Record management can be controlled via Bosch Video Recording Manager (VRM); in alternatively the camera can directly use the iSCSI destinations without the need for software by recording.

Project co-financed by the European Regional Development Fund

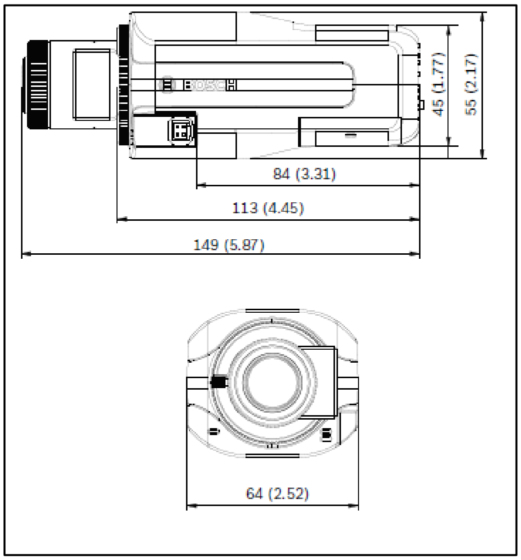


Figure 8.3: Video camera dimensions

Table 8.2: Video camera characteristics

Video Camera	Quantity
▪ Alimentation: 12Vdc Power over Ethernet 48 Vdc nominale ▪ Absorbed current: 300ma (12Vdc), 75ma (PoE 48Vdc) ▪ PoE: IEEE 802.3af (802.3at type 1), Power Level Class I ▪ Working temperature: -30°C, +50°C ▪ Relative Humidity: <90% ▪ Streaming Video: 1080p ▪ Compression Video: H.264 (MP); MPEG ▪ IP total lag: 120ms-340ms ▪ Noise reduction: iDNR ▪ Optical lens: Varifocal 3,3 mm to 12 mm, DC-Iris D1.4-360, with IT correction ▪ Analogic Video output: CVBS, 1VPP, 2,5 mm jack, 75 Ohm ▪ Memory: Support to SDHC card 32GB or SDXC card 2TB ▪ Networks Protocol: IPv4, IPv6, UDP, TCP, HTTP, HTTPS, RTP/RTCP, IGMP V2/V3, ICMP, ICMPv6, RTSP, FTP, Telnet, ARP, DHCP, NTP (SNTP), SNMP (V1, MIB-II), 802.1x, DNS, DNSv6, DDNS (DynDNS.org, selfHOST.de, noip. com), SMTP, iSCSI, UPnP (SSDP), DiffServ (QoS), LLDP, SOAP, Dropbox, CHAP,digest authentication ▪ Dimensions: 55x64x146mm (with optical lens)	2

Project co-financed by the European Regional Development Fund

9 Annex D

TAI Traffic Analysis System

The traffic analysis (enabled for TAI adaptive lighting) includes:

a. *1 WTC (Cod. 61210)*, Wise Traffic Controller, detection unit and traffic data processing in transit with communication GPRS to the supervision system
b. *1 CLOUDX ITA 2 WTC* (Cod.66129-ITA2WTC), WTC cloud hosting + SIM GPRS supply

WTC

It is Wise Traffic Controller, that is detection unit and traffic data processing in transit with communication GPRS to the supervision system. It is an optic sensor that allow to obtain in real time data about traffic vehicles on urban and extra-urban roads: it is able to distinguishing 3 categories (motorcycles, car and trucks), detecting the overall average speed and program the public illumination according to the traffic typology.

Figure 9.1: Wise Traffic Controller

Table 9.1: WTC characteristics

WTC (Wise Traffic Control)	Quantity
▪ Alimentation: 5Vcc ▪ Power supplied: Max 5W ▪ Absorbed power by WTC: 1,5W ▪ Absorbed power by powerline module: 3W ▪ Working temperature: -10°C, +70°C ▪ Electric isolation class: III ▪ IP protection: IP65 ▪ Dimensions: 52x98x45mm ▪ Weight: 400g ▪ Communication technology: convoyed waves, GPRS, Ethernet ▪ Installation: on support high 6 meters ▪ Traffic control on 4 traffic lanes ▪ Monitoring every day or every hour ▪ Determination of average speed of the vehicle ▪ Counting of vehicles number and data storage	1

Project co-financed by the European Regional Development Fund

▪ Max configuration per cabinet: 10 WTC	

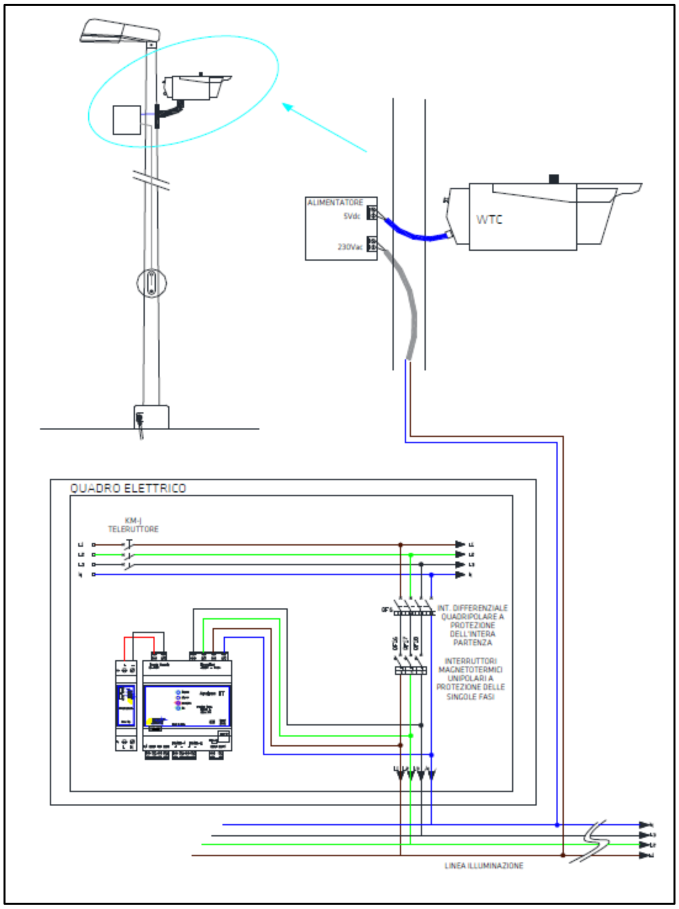


Figure 9.2: Connection between Control Cabinet and WTC

Project co-financed by the European Regional Development Fund

10 Annex E

Web Platform for Monitoring lighting system

In this Annex is described the Wep Platform form monitoring activities presented in 3.8.

The main screen of the Web Platform is represented in the figure below: from here it is possible to access to every information, as current level of energy consumption, electrical data, weather data (temperature, pressure, wind data, rain data), traffic analysis or video-surveillance ; there is also the possibility to have historic series of every kind of data.

In figures Figure 10.1-Figure 10.6 is presented the Web Platform functionalities related to the electrical monitoring, and in figures Figure 10.7-Figure 10.14 are presented the functionalities of the additional smart services implemented on the same platform about the weather monitoring. In Figure 10.15-Figure 10.21 are presented others smart integrations as Traffic Analysis and Video Surveillance, that refer to new Web Platforms and new Data Service

The main screen of Web Platform is the dashboard with the list of all Electrical Cabinets monitored and remotely controlled by Abruzzo Region. On the top of the list, QE01, the location of Pescara Esmartcity Pilot. It is possible individuate all the cabinets on a map.

Project co-financed by the European Regional Development Fund

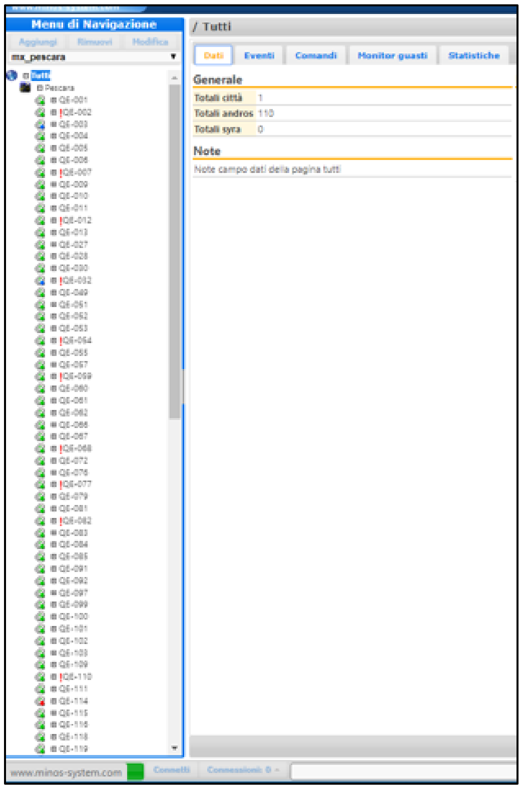


Figure 10.1 Main dashboard of web monitoring portal - total number of cabinets

The operator can retrieve the most important general system information, selecting the Cabinet on the list. Therefore, selecting QE01 (Esmartcity Pilot) it is possible to learn about general data, working data on devices (temperature, alimentation, active services), verify the current level of energy savings in kW together with the current level of energy consumptions, the number of installed gateways and controllers in the system and their operating status and eventual misfunctions.

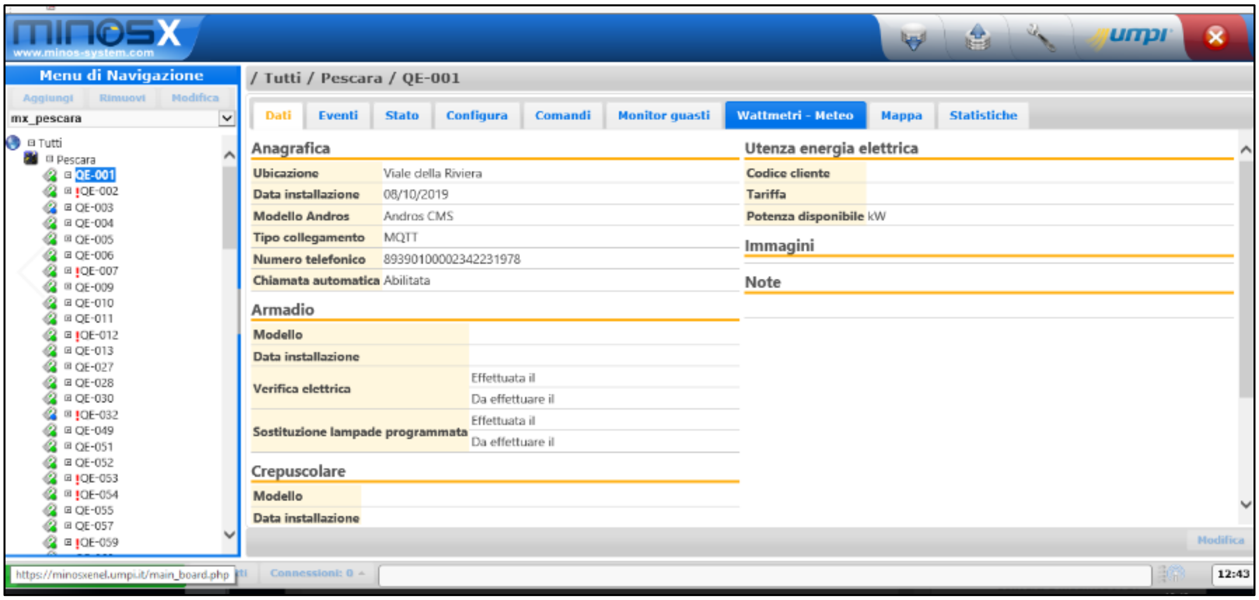


Figure 10.2: General data on the Cabinet

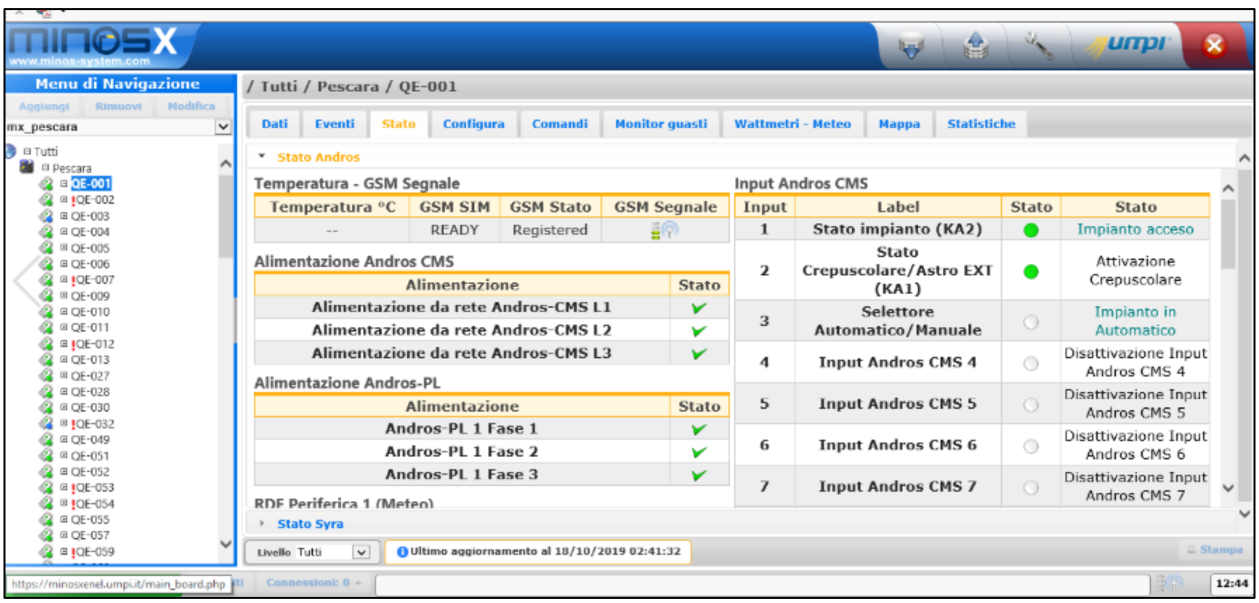


Figure 10.3: Working Data and active services on the Cabinet

Project co-financed by the European Regional Development Fund

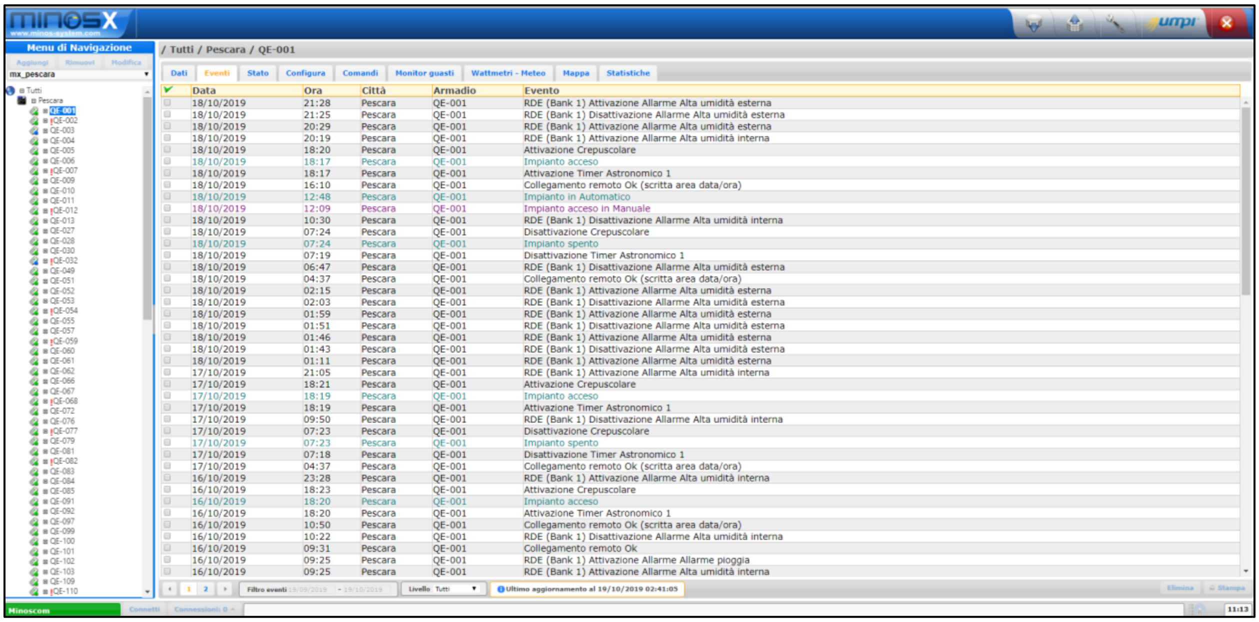
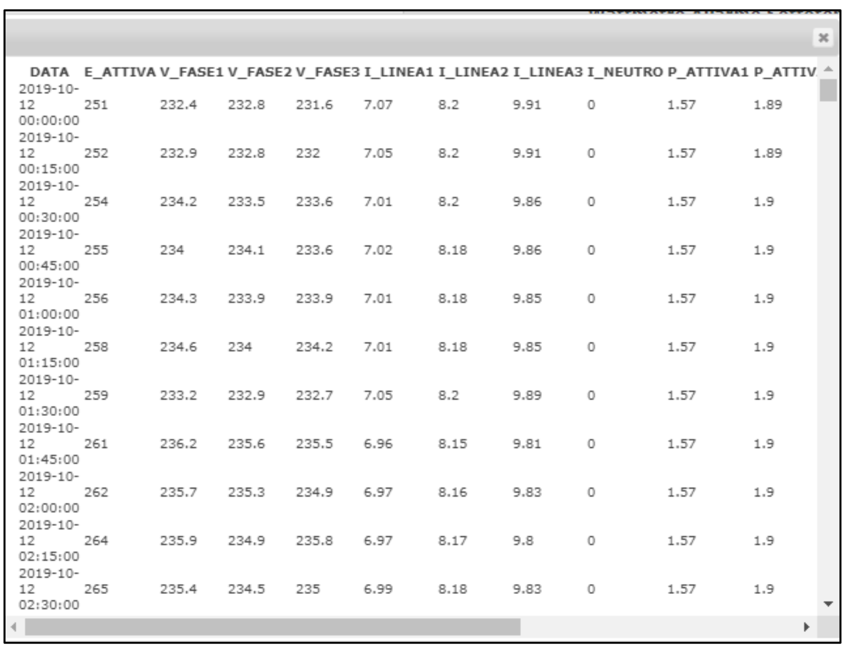


Figure 10.4: Events recorder

As reported in the image below, is possible extrapolating all the data for a history series (in the example, has been reported the data about current consumption from 12/10/2019, when the system was operative for the first time).



DATA	E_ATTIVA	V_FASE1	V_FASE2	V_FASE3	I_LINEA1	I_LINEA2	I_LINEA3	I_NEUTRO	P_ATTIVA1	P_ATTIV
2019-10-12 00:00:00	251	232.4	232.8	231.6	7.07	8.2	9.91	0	1.57	1.89
2019-10-12 00:15:00	252	232.9	232.8	232	7.05	8.2	9.91	0	1.57	1.89
2019-10-12 00:30:00	254	234.2	233.5	233.6	7.01	8.2	9.86	0	1.57	1.9
2019-10-12 00:45:00	255	234	234.1	233.6	7.02	8.18	9.86	0	1.57	1.9
2019-10-12 01:00:00	256	234.3	233.9	233.9	7.01	8.18	9.85	0	1.57	1.9
2019-10-12 01:15:00	258	234.6	234	234.2	7.01	8.18	9.85	0	1.57	1.9
2019-10-12 01:30:00	259	233.2	232.9	232.7	7.05	8.2	9.89	0	1.57	1.9
2019-10-12 01:45:00	261	236.2	235.6	235.5	6.96	8.15	9.81	0	1.57	1.9
2019-10-12 02:00:00	262	235.7	235.3	234.9	6.97	8.16	9.83	0	1.57	1.9
2019-10-12 02:15:00	264	235.9	234.9	235.8	6.97	8.17	9.8	0	1.57	1.9
2019-10-12 02:30:00	265	235.4	234.5	235	6.99	8.18	9.83	0	1.57	1.9

Figure 10.5: Example of History Series of Data

Project co-financed by the European Regional Development Fund

The Web Platform can used for particular configurations and commands, as the automatic regulation of lighting level depending of other data (represented below, ad traffic analysis and weather conditions), improving energy saving. Therefore the possibility is a report of the data analysis in the form of data-driven self-regulation and optimization, what causes the action which changes the original dimming schedule.

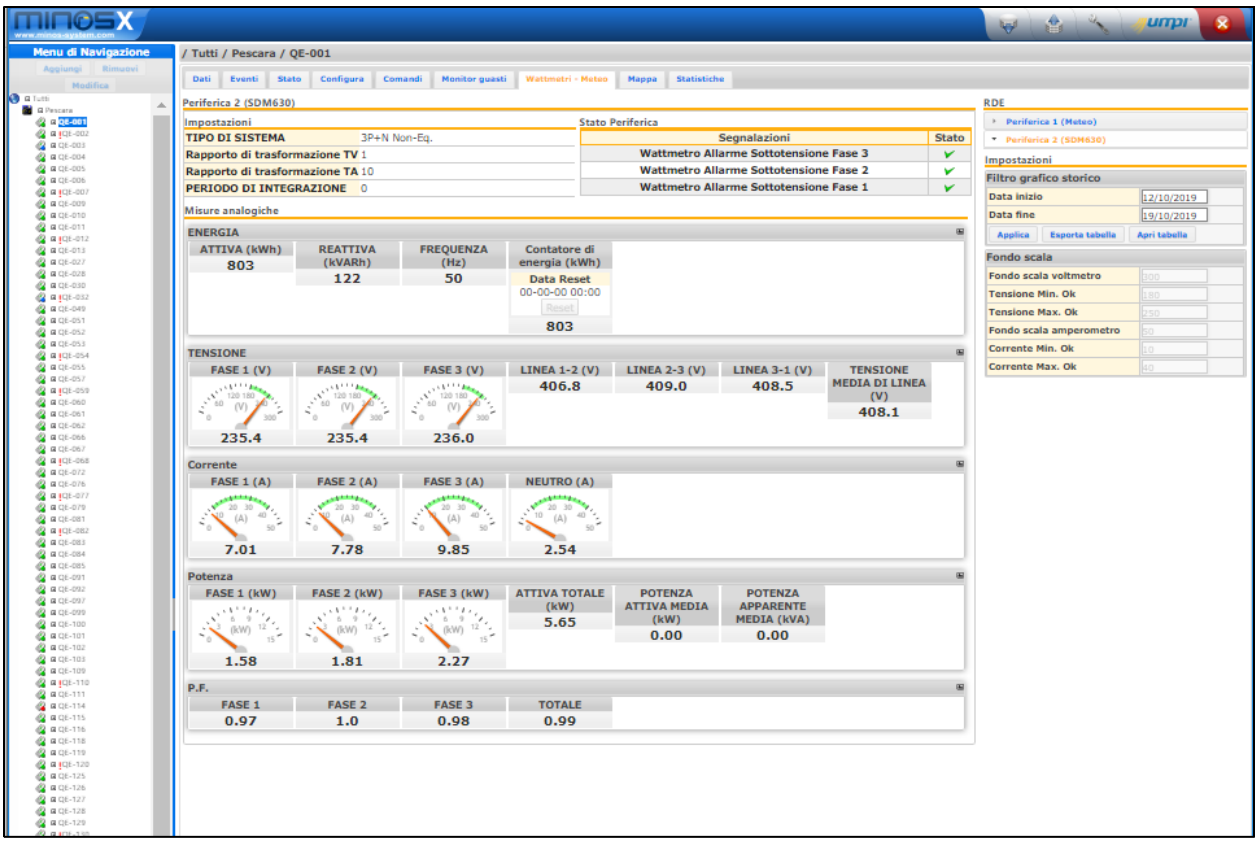


Figure 10.6: Energy, electric and power data on the cabinet with the possibility to export Data

On this base, the Esmartcity project integrate firstly this Web Platform with the Weather Station data. In figures below all the maturations, that can be correlate with remote control of lighting devices.

Project co-financed by the European Regional Development Fund

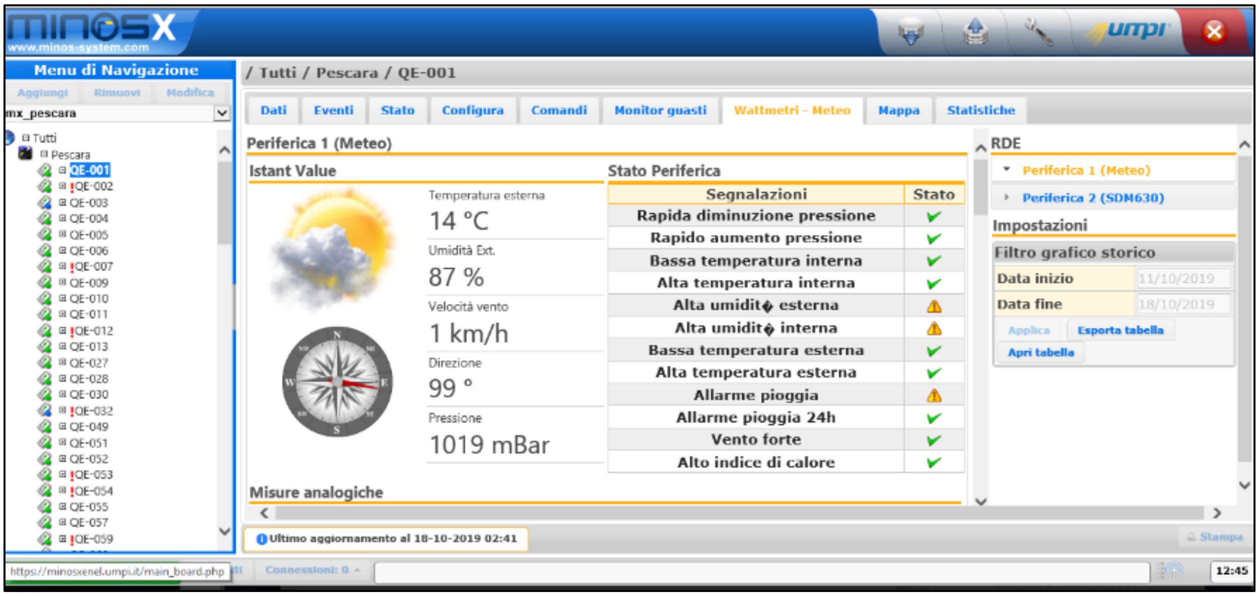


Figure 10.7: Weather Parameters on QE01 (temperature, wind data, pressure)

There are many functionalities on monitoring weather data with graphical supports.

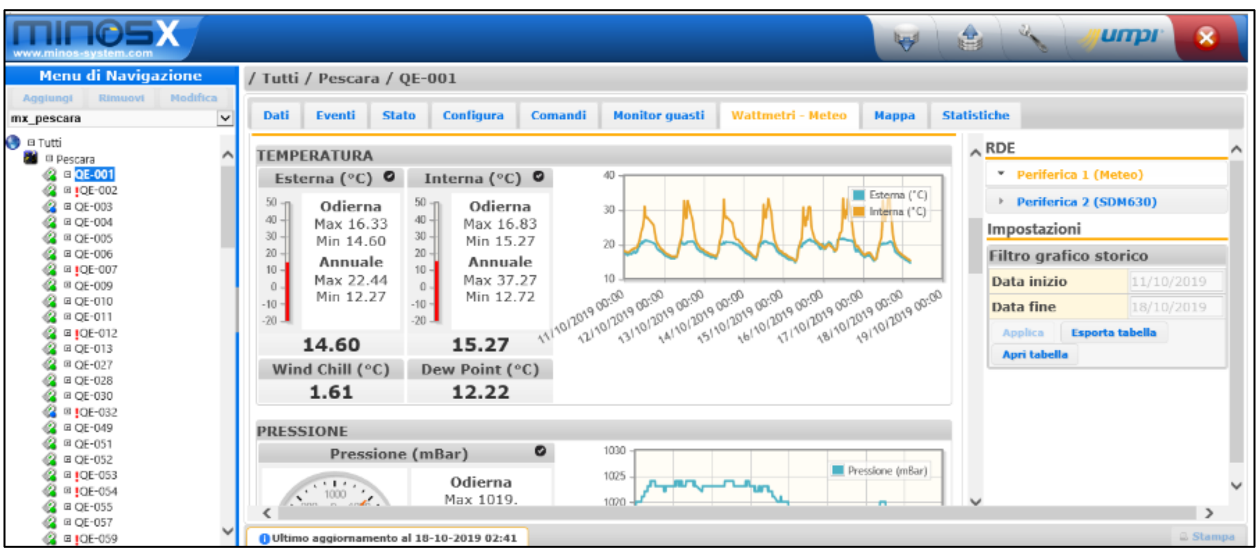


Figure 10.8: Indoor and outdoor temperature trend from 10/11/2019 to 18/10/2019

Project co-financed by the European Regional Development Fund

Figure 10.9: Pressure trend from 10/11/2019 to 18/10/2019

Figure 10.10: Wind data and trends from 11/10/2019 to 18/10/2019

Project co-financed by the European
Regional Development Fund

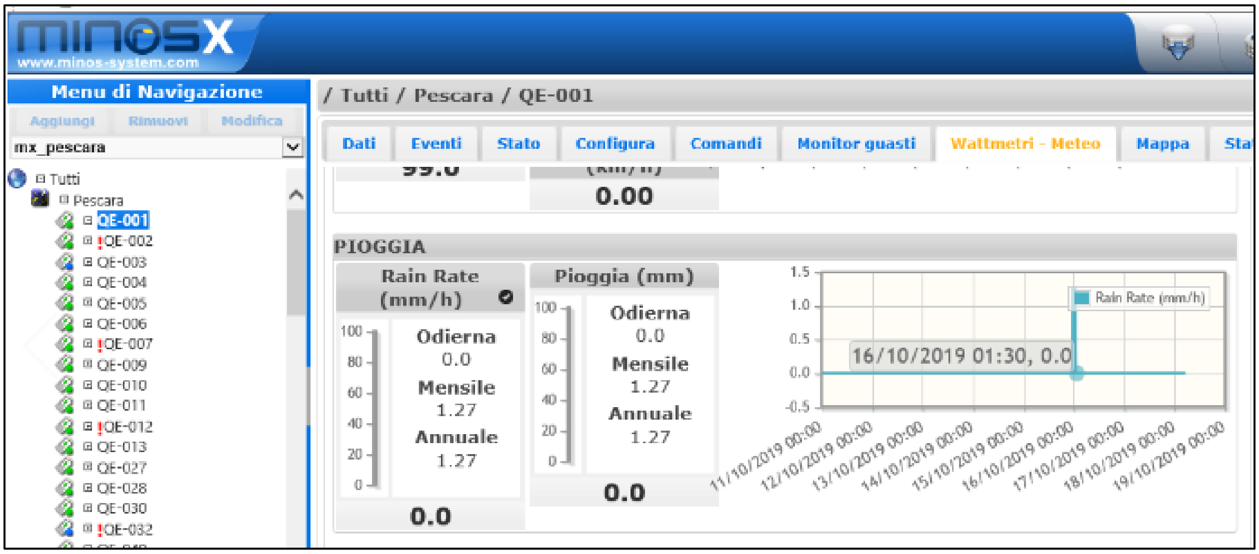


Figure 10.11: Wind data and trends from 11/10/2019 to 18/10/2019: it is observed a rain event in the 16/10/2019 at 00:00 with 1mm rainfall

Figure 10.12: Humidity data and trends from 11/10/2019 to 18/10/2019

Project co-financed by the European Regional Development Fund

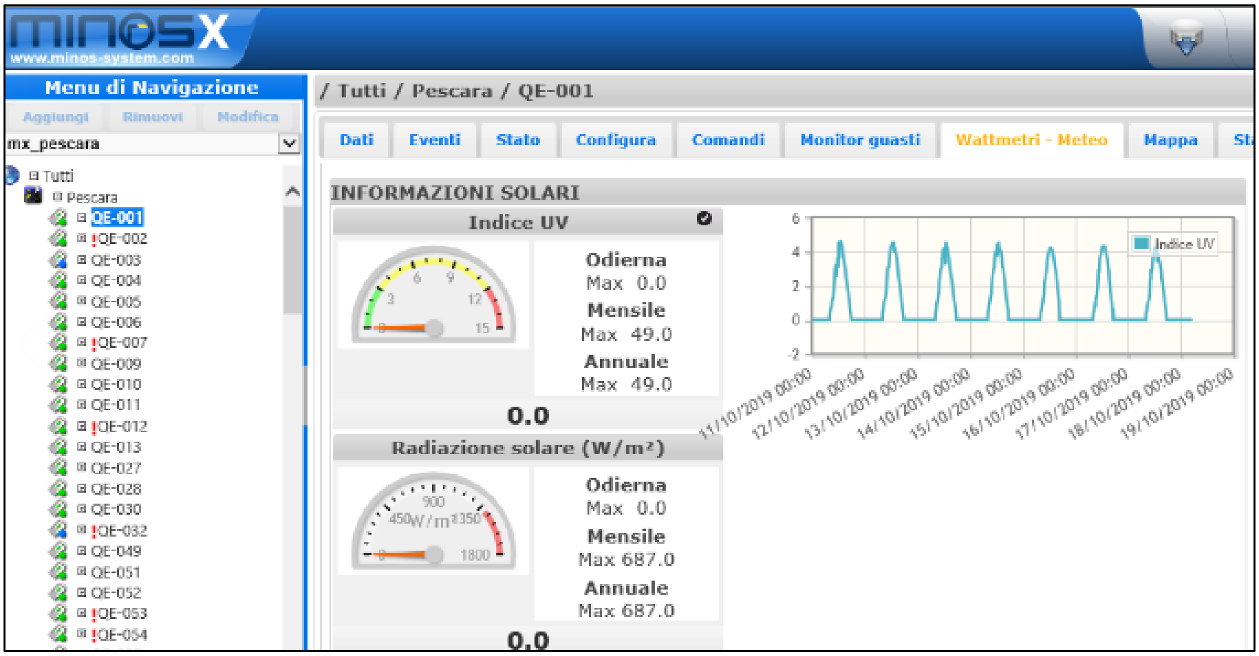


Figure 10.13: Solar data and trends from 11/10/2019 to 18/10/2019

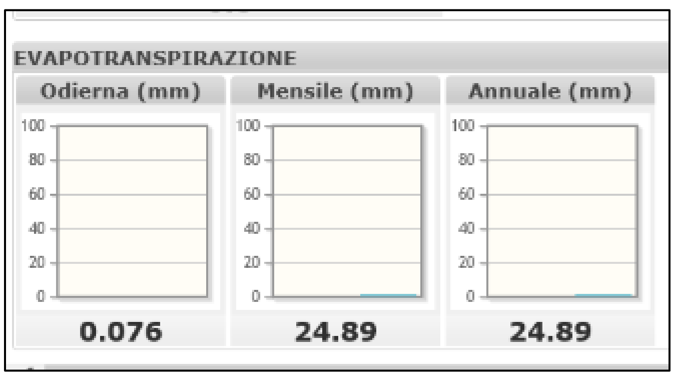


Figure 10.14: Quantity in mm of water from the ground into the air in the vapor state (daily, mouthy, annual)

The other smart implementations are the video surveillance and traffic analysis and monitoring (described before). This smart integrations require a new web platform, that integrate the existent (with the new smart features described before about weather monitoring and support on auto-dimming depending on the data collected). The total results is a remote control that allows to the operator to control the switching on and off of the lamp and to adjust the luminous flux in order to check the energy savings.

The video-surveillance function is specially useful for monitoring the security of the area, both in terms of vandalism and security for citizenship. The components have been described. There is

Project co-financed by the European Regional Development Fund

therefore a dedicated web portal from which you can observe the live movement (with a 15-second update interval) and go back to the recordings of the last two weeks.

The Data Center presents the result of the data analysis in the form of data-driven self-regulation and optimization, what causes the action which changes the original dimming schedule. This current schedule is result of the analysis of the citizens habits, including pedestrians and cars moving for days in a week, week in a month or some specific part of a year. The simple model explanation is finding optimal working regime for the maximum energy saving against less dimming actions as possible (to avoid bulb damaging and decreasing bulbs lifetime). Some other parameters are also in the calculations, but the figure describes only the basic level.

There are two cameras, on North and South directions waterfront.

Figure 10.15: Video-surveillance software (Nord direction, image live of 18/10/2019)

Project co-financed by the European Regional Development Fund

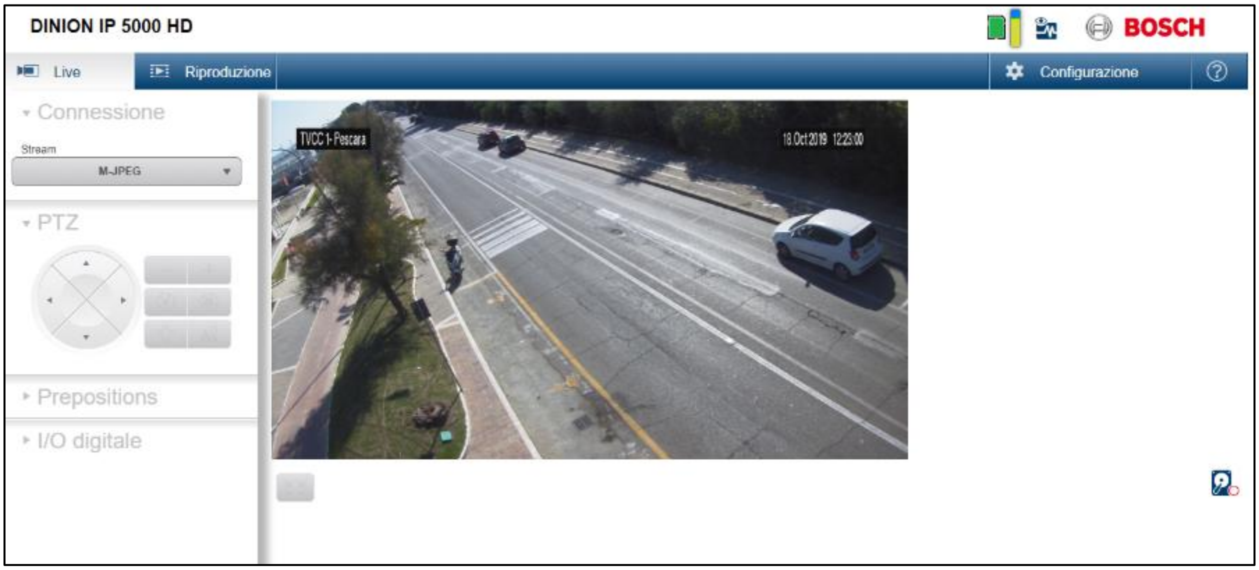


Figure 10.16: Video-surveillance software (Sud direction, image live of 18/10/2019)

The last feature implemented on a new platform is TAI (Traffic Analysis). Bypassing the technical characteristics of the components (already described), it is emphasized that this functionality has multiple functions, functional to the system obtained (self-regulation of the lighting in view of energy savings), but also functional to future objectives: for example, using such a TAI system in the whole city, you can have total control of city traffic, which involves utility in public safety but also in the management of the flow of city traffic, giving directions live to the citizen and thus minimizing travel times.

Project co-financed by the European Regional Development Fund

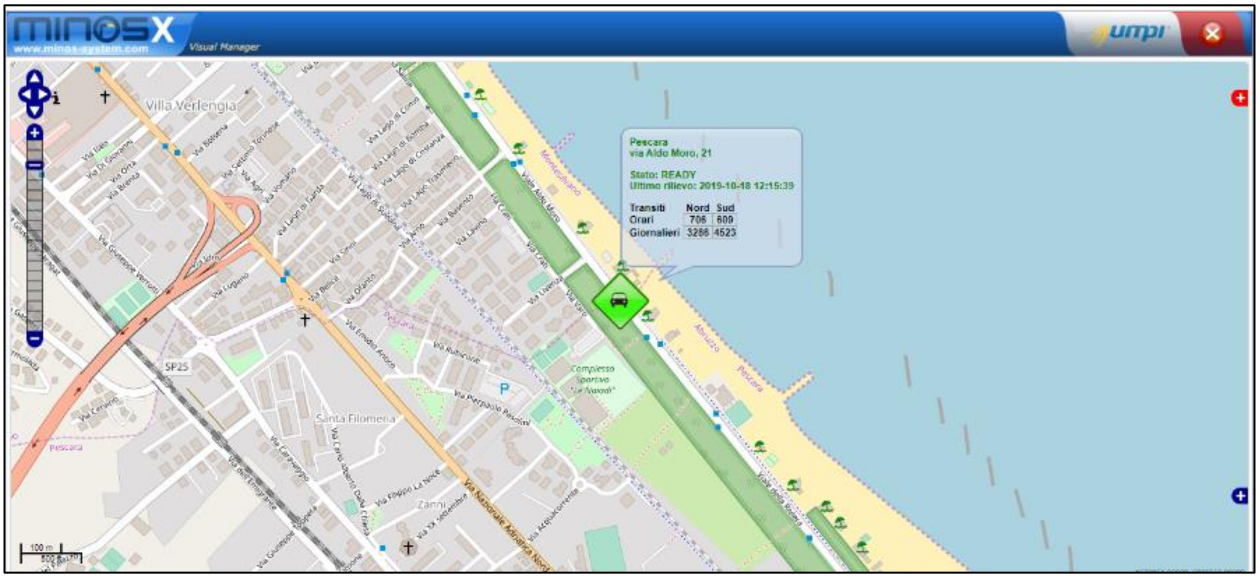


Figure 10.17: TAI Web Platform: vehicles counting in both directions

In example, in the precedent figure we can notice that, in the Pescara city in 18/10/2019 until 12:15 PM, there was a greater flow in Sud direction instead of North. So, this feature is useful to learn about citizens habits.

It si possible to deduce the history traffic flows in a given time interval, or deduce cars velocity, in one direction, or both directions.

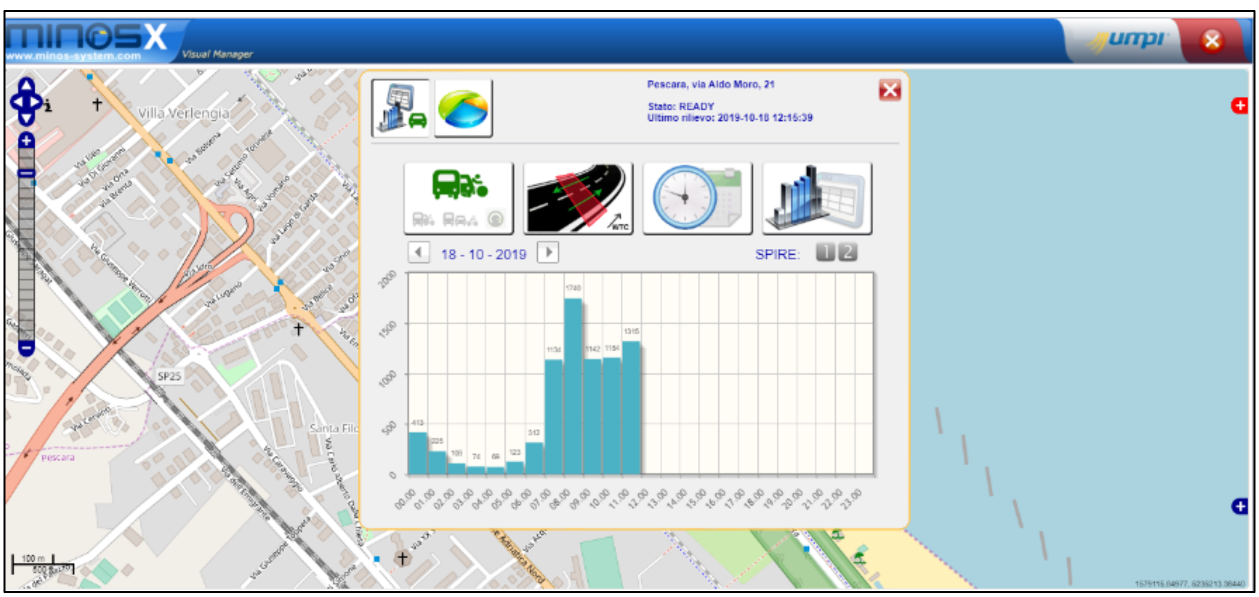


Figure 10.18: Graphic about traffic vehicles flow in Nord and Sud direction togheter(18/10/2019 until 12:15 PM)

Project co-financed by the European Regional Development Fund

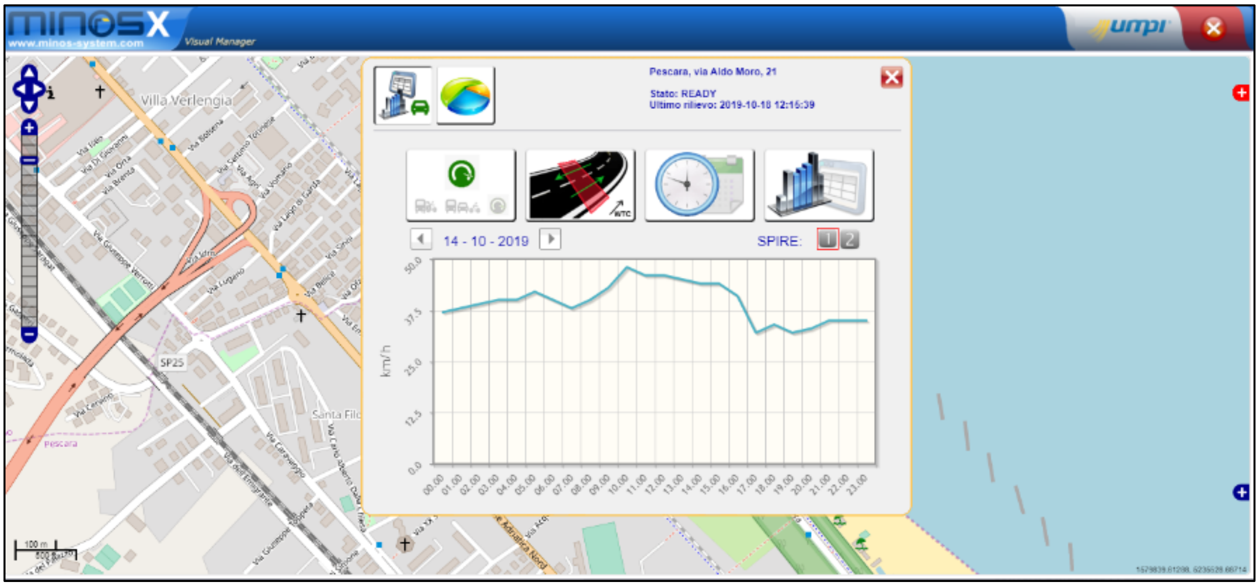


Figure 10.19: Graphic about vehicles velocity in Nord and Sud direction togheter (14/10/2019 until 12:15 PM): it notice that there is a pick of velocity in 10:10 AM)

Finally, there is a mouthy analysis of the traffic, with a graphic support, in holidays and working days. From the two figures below, we can notice that in waterfront Primo Vere in Pescara there is a greater traffic in working day instead of Holidays.

Project co-financed by the European Regional Development Fund

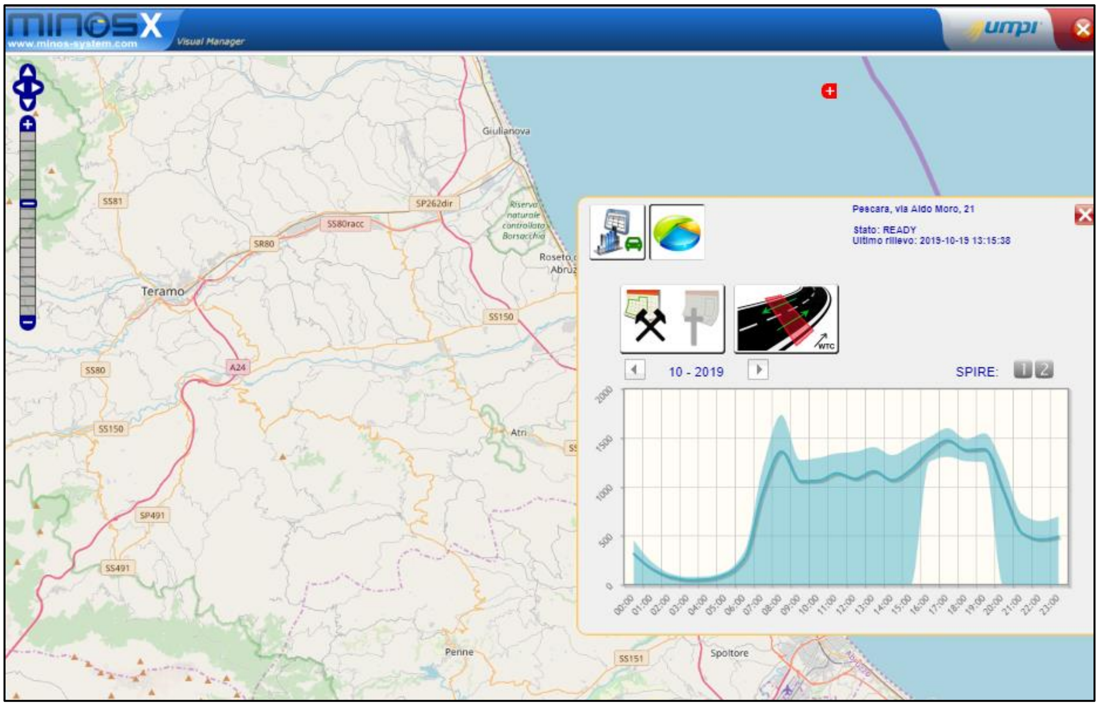


Figure 10.20: Traffic flow in working days in October (until 18/10/2019)

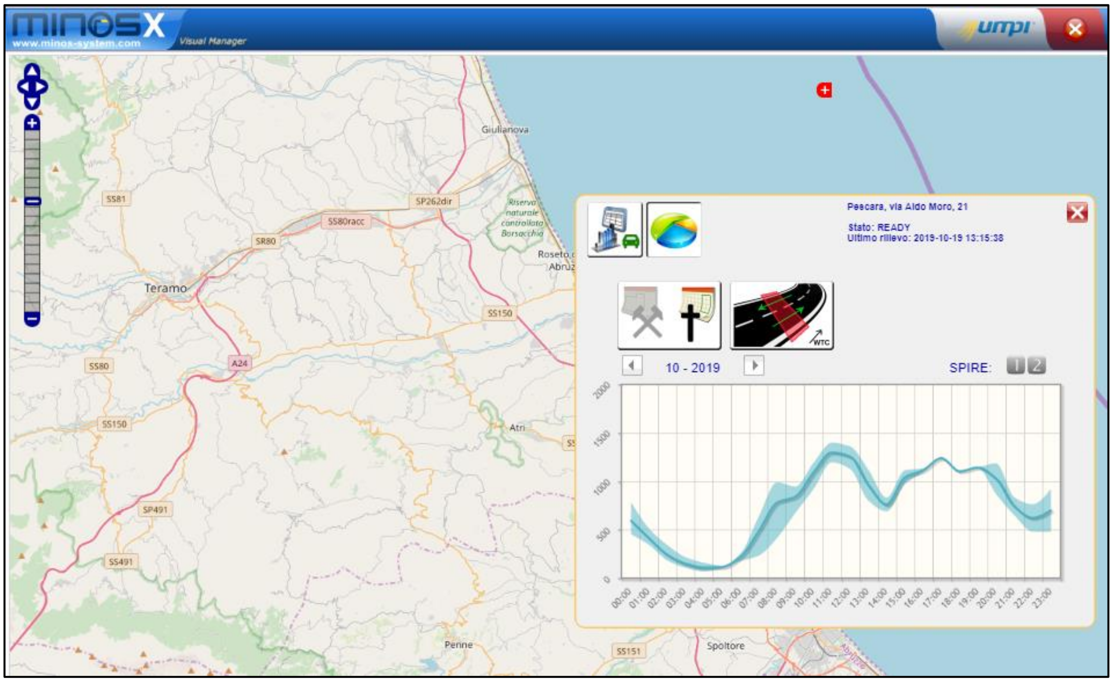


Figure 10.21: Traffic flow in holydays in October (until 18/10/2019)

11 Literature

1. **Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N. M., & Nelson, L. E.** Helping CIOs Understand "Smart City" Initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO. 2010, Vol. Inc. Available at http://public.dhe.ibm.com/partnerworld/pub/smb/smarterplanet/forr_h.

2. **Miorandi, D., Sicari, S., De Pellegrini, F., & Chlamtac, I.** Internet of things: Vision, applications and research challenges. Ad hoc networks, 10(7), 1497-1516. 2012.

3. **Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M.** Internet of Things (IoT): A vision, architectural elements, and future directions. Future generation computer systems, 29(7), 1645-1660. 2013.

4. **Serpanos, D., Wolf M.** Internet-of-Things (IoT) Systems Architectures, Algorithms, Methodologies. Springer International Publishing.

5. ***Wikipedia.* [Online] https://it.wikipedia.org/wiki/Storia_di_Pescara.**

6. Gandy, Matthew. Negative Luminescence. *Annals of the American Association of Geographers,.* 107:5, 1090-1107, 2017, DOI: 10.1080/24694452.2017.1308767.

7. *"Cost analysis of smart lighting solutions for smart cities", 2017 IEEE International Conference on Communications (ICC),.* G. Cacciatore, C. Fiandrino, D. Kliazovich, F. Granelli and P. Bouvry. Paris : s.n., 2017. pp. 1-6. doi: 10.1109/ICC.2017.7996886.

8. Inc., Navigant Consulting. *Smart Street Lighting as a Smart City Platform, White Paper .* 2017.

9. Ferrarini, Luca. *EU Interreg MED Esmartcity Pilot Deployment Operational Plan Framework.* s.l. : Development Agency of the City of East Sarajevo (RAIS), 2018.

10. Authority, Israel Innovation. http://innovationisrael-en.mag.calltext.co.il/magazine/41/articles/435. [Online]

11. *Determinants of Longevity of Smart City Innovation Ecosystems and Projects.* Merle Stadhouders, Tobias Brandt, Koen Dittrich. s.l. : MSc Business Information Management, Rotterdam School of Management, Erasmus University Rotterdam, Cisco Systems International B.V.

12. https://www.agendadigitale.eu/smart-city/smart-city-per-uneconomia-sostenibile-sfide-e-opportunita-di-business/. [Online]

13. Glišić, Branko and Inaudi, Daniele. *Fibre Optic Methods.* s.l. : Wiley, 2007.

Project co-financed by the European Regional Development Fund

12 List of Figures

Project co-financed by the European Regional Development Fund

Project co-financed by the European Regional Development Fund