Ref. Ares(2018)6152153 - 30/11/2018

Nantes | Hamburg | Helsinki

my SMART Life

Deliverable due date: M24 – November 2018

D2.15 Design and implementation of public lighting concept

WP2, Task 2.8

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife		
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**		
Project Duration	1st December 2016 – 30th November 2021 (60 Months)		
Deliverable	D2.15 Design / Implementation / Public Lighting concept		
Diss. Level	PU		
Status		Working	
		Verified by other WPs	
	■	Final version	
Due date	30/11/2018		
Work Package	WP2		
Lead beneficiary	ENGIE		
Contributing beneficiary(ies)	CAR, NAN		
Task description	Task 2.8: Public lighting improvements: A new public lighting concept will be designed and implemented by ENG. Setup of distance management, determining the type of material to install in order to adapt the current equipment as well as the definition of gradation scenarios. All public lighting energy data will be integrated into the Nantes Urban platform. D2.15: Design and implementation of public lighting concept Report on the new public lighting concept and integration of data into the urban platform of the city of Nantes		
Date	Version	Author	Comment
01/08/2018	0.1	ENG	First version
29/11/2018	0.2	ENG	Version integrating comments from reviewers
30/11/2018	0.3	CAR	Overall final review

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table of Content

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table of Figures

This project has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement No 731297.

Table of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Abbreviations and Acronyms

Acronym	Description
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
LoRa	Long Range
IoT	Internet of Things
CCTV	Closed Circuit Television
LED	Lighting Emitting Diode
KPI	Key Performance Indicator
IP	Internet protocol

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

1. Executive Summary

This deliverable D2.15 “Design and implementation of public lighting concept” describes the action n°18 “Public Lighting Optimization” implemented by ENGIE to validate the following concepts:

- Monitor Energy consumption for optimisation of maintenance and energy bills
- Adapt the lighting to the using
- Increase security by anticipating in real time when breakdown appears

The area chosen for this implementation is a mixed-used pedestrian zone with housing and night life where public tranquillity has to be improved. Besides, this area has undergone an urban transformation over the past decade.

The aims of the project are to:

- Adapt the lighting system to urban transformation: reduce the noise and pedestrian circulation in the new housing zone,
- Improve the lighting in the path used by people by night to secure the area
- Increase security by anticipating in real time when breakdown appears
- Pilot the extinction of the lamps in a specific zone for special event in real time
- Reduce energy consumption with new and efficient equipment

This urban context allows us to implement the required lighting functionalities which are:

- Energy monitoring of LED luminaires,
- Dimming of LED luminaires when people are detected,
- Remote control the lighting,

To respond at this aim, 65 luminaires were equipped with nodes for street lighting control and some of them have presence detection.

A LoRa infrastructure was created to have a private IoT network.

A lighting management system was implemented allowing supervising each luminaire remotely.

The lighting system was commissioned in September 2018 by ENG. During the 3 years of exploitation, and in order to demonstrate the interest of replication, ENG and NM are expecting to do the following:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- Be a cost driven solution that is less expensive in global costs than existing solution with discharged lamp on a 15 years projection.
- Confirm expected 78% of energy and CO_2 emission savings.
- Interest of implementation of IoT interoperable technologies using a large network at metropole scale (this network could be used for others system infrastructures such as traffic management, bus priority system management, flood detection, CCTV, etc.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

2. Introduction

2.1 Purpose and target group

This deliverable is linked to action n°18 “Public Lighting Optimization” implemented by ENGIE to validate following concepts:

- Monitor Energy consumption for optimisation,
- Dim the lighting level to the people need
- Increase security by anticipating in real time when lamps need to be replaced reports on the design

The purpose of this deliverable is to explain what solution was implemented (design / works / expectations). The results of this action will be shared and accessible via NM Platform Urban Data.

2.2 Contributions of partners

The following depicts the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution of partners

Participant short name	Contributions
ENG	Design installation, provision and installation of the streetlight control, installation of luminaires
NAN	Provision of LED luminaires

2.3 Relation to other activities in the project

Table 2**:** Relation to other activities in the project

Deliverable Number	Contributions
D2.1	This deliverable provided the baseline of Nantes demonstration area
D2.2	This deliverable provides the simulation models of the building stock, energy system, transportation, urban infrastructures
D2.16	This deliverable provides the functional requirements, software architecture and data structures through the creation of a common framework for the 3 LHCs urban platforms
D5.1	This deliverable provides the integrated evaluation procedure.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

3. Design of smart lighting concept

Smart lighting is a key issue in terms of urban transformation strategy for smart cities. Two opportunities are emerging on this market. The first one is linked to LED technology that has arrived at a maturity. Nantes Metropole adopted LED technology 3 years ago. It is becoming evident that cities need to retrofit their former sodium lighting luminaires. The second one is linked to IoT solution deployment. It is now possible to address individually each luminaire allowing operators to optimize real time energy efficiency and maintenance costs.

3.1 Perimeter

Figure 1: Previous situation – Plan

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The area chosen is a nice pedestrian zone along the Loire river, that is just next to the very busy “Quartier des Machines”, where tourists, businessman, inhabitants, students are mixing together at day and night in the Island of Nantes district.

Figure 2: “Quartier des Machines”

At night, the “Quartier des Machines” is very attractive for students that are meeting together in a festive way.

While coming back home, inhabitants from the area just next to this Quartier need to feel safer and to gain in tranquillity. The pedestrian way along Loire River was not lighten enough because lamps where not systematically fixed when out of order.

Besides, the area has undergone an urban transformation with construction of new residential buildings. In order to avoid complaints from inhabitants with an impact of light and noise on their sleep, a lighting system has to be a part of urban strategy.

Something needed to be done.

3.2 Design purpose

The design of smart lighting concepts follows 3 purposes:

- Energy efficiency = the solution should demonstrate energy and CO_2 savings compared to standard
- Interoperability = the solution should demonstrate open data compatibility for easy supervision
- Cost driven = the solution should be affordable compared to existing solution

If those 3 purposes are reached, then the design of the solution is widely deployable.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

3.3 Technical design

3.3.1 Overall system architecture

3.3.1.1 Description

The system is based on communicating sensors deployment and supervision platform implementation that enables street lighting infrastructure monitoring and control, answering the following needs: luminaire remote management, presence detection, citizens guiding.

FLASHNET

Figure 3: Flashnet logo

The solution used is FLASHNET's InteliLIGHT system, using IoT (Internet of Things) communication technology.

Flashnet is a technology company based in Brasov, Romania, that integrates hardware and software in order to develop intelligent services for smarter cities. Their vision is to improve urban synergy and people's lives through continuous research and development.

This system enables:

- Autonomous switching on/off and dimming,
- Network knowledge and optimization,
- Preventive and curative maintenance planning, and enable predictive maintenance
- Operating optimization,
- Smart City integration (based on mesh technology)

LoRa was chosen as the network protocol for IoT fittings as it is standard and wide-open solution that is compatible with more and more IoT sensors.

This kind of wireless solution is very convenient when retrofitting because extra wires could be very expensive if they later needed to be installed underground.

Also, LoRa technology allows operators the possibility to install any compatible sensors that could be addressed by the gateway with the geographical perimeter of lighting installation. This opens new horizon for implementing some smart IoT requiring a network within the city at lower cost. In the solution that was implemented, the LoRa gateway has 2km range. The only limitation is the bandwidth of the LoRa network.

The bandwidth of the LoRa network. is designed for small size of data. For example, CCTV data required another and specific bandwidth.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

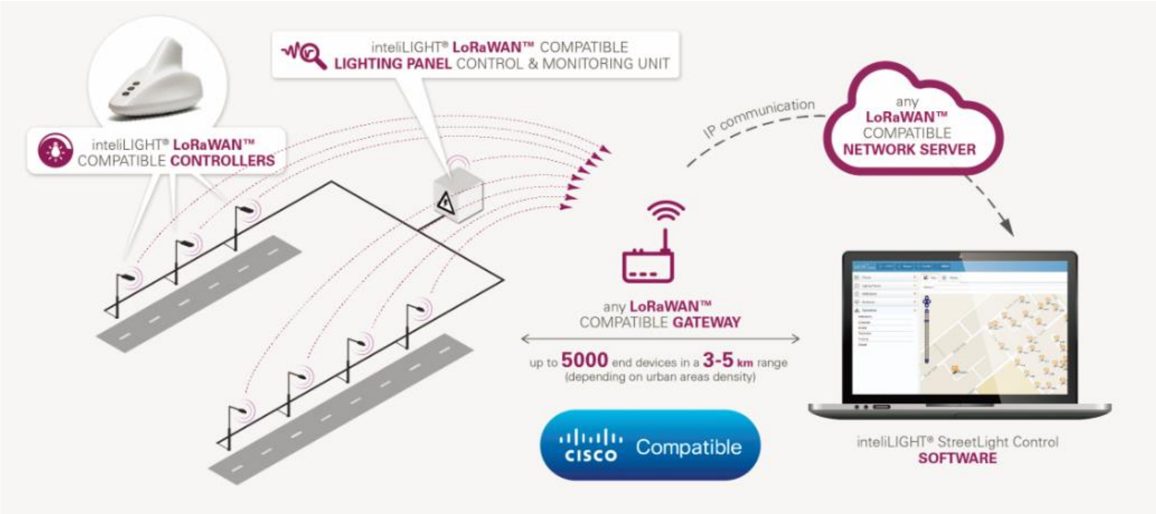

Figure 4: System architecture

Device controllers installed on the luminaires send the data to the gateway using the LoRa network. The gateway transmits the data to a network server using IP communication or mobile data network (SIM). Then the data is reachable from the supervision web platform InteliLIGHT StreetLight Control by Flashnet. The Flashnet system is bi-directional and the Information from the device controller take the reverse way.

Flashnet's system is used in all over the word. In Europe the implementations are indicated in this card:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Figure 5: Implementation of Flashnet Systems in Europe

The platform collects data about luminaires such as electrical consumption, lighting state (on/off/dimming), schedule programmed and currently running, sensor settings.

The KPI (defined in chapter 4.3.3) will be provided to the Urban Platform by means of APIs. Other data – consumption, functional status, etc. - are available and will be shown on the Urban Platform on a per case basis, i.e. based on agreed use cases.

3.3.1.2 Functions

The street lighting remote management system provides the following functions:

Lighting Supervision

- Manual remote management: switching on/off, dimming
- Schedule programming
- Real-time control and monitoring
- Geographical view of sensors network
- Luminaire area grouping and control
- Possible link with CMMS (Computerized maintenance management system)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

User Management

- Several programmable profiles
- Access and modification rights configuration
- Areas and groups assignment

Failure detection

- Luminaire error and failure display
- Email notifications configuration

Luminaire monitoring and history

- Failure detection
- Working time
- Energy consumption

3.3.1.3 Supervision architecture

On the supervision platform, the lighting network is structured following this organization:

Figure 6: Supervision architecture

Administrative Unit (tree structure)

These groups contain one or several Lighting Panels. Users must be assigned to Administrative Unit to be able to monitor or control the belonging lighting network.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Each Administrative Unit has a Scheduler used for scheduling programming.

Lighting Panels

Lighting Panels are used to represent real electricity cabinets, providing a visualization of the physical electrical network.

Device Controller

“Device Controllers“ allow sensors to be physically identified in the system with a logical address. It corresponds to end-nodes of the system (luminaire, sensor, etc.). Every controller is associated with a Lighting Panel to know where they are powered from.

3.3.2 System specifications

3.3.2.1 Device Controllers

Three types of device controllers from FLAHSNET are used. Linked to a luminaire, they enable:

- Data transmission to the gateway by LoRaWAN
- Luminaire lighting state monitoring
- Power failure detection
- Luminaire energy consumption

Figure 7: inteliLIGHT fittings

This project has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 3: Description of fittings used

Fitting type	Integration Mode
FRE-220-NEMA	Placed on the light top using NEMA connection
FRE-220-M	Embedded in the light structure
FRE-220-P	Installed into the lighting pole

3.3.2.2 Gateway

kerlink
communication is everything

Figure 8: Kerling system

It is a LoRa IoT Station manufactured by KERLINK.

Founded in 2004, Kerlink is a french fast-growing, global and publicly traded provider of Internet of Things (IoT) infrastructure, software and services serving telecom operators, public authorities and businesses of all sizes to design, launch and operate IoT networks.

It collects the data sent by controllers and transmit it to the network server using mobile data network (a SIM card is placed in the gateway). In the opposite direction, manual orders and schedule modifications can be sent to controllers.

Capacity: up to 5000 devices

Range: 2 km in urban area

Figure 9: Gateway

3.3.3 Luminaires specifications

Switching ON/OFF

Switching on and off the lights doesn't request high-level features. Even basic luminaires can be controlled through the power supply wiring.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Dimming

Most of the luminaires equipped with InteliLIGHT system are designed to work with 1-10V or DALI interface. InteliLIGHT system allows operators to use both to dim the lights.

As explained before, different types of sensor allow for different ways of integration into the luminaire. Whether in the lighting pole, in the light structure or on top of the light, you are free to choose the sensor that suits your luminaire best.

3.3.4 Budget projection for 15 years

Project expenses:

Table 4: Project Expenses

Investments costs HT		
ENGIE	72 000€ (grant 32000€) - Design and works: 62 000€ - Equipment: 10 000€	Design, provision and installation of street lighting control system, Design and installation of lighting matt and lamp
Nantes Metropole	49 200€	Provision of 14 supports and 42 luminaires
Nantes Metropole	21800€ *budget not included in energy and cost saving calculation	Classic lighting works in the same area around mySMARTLife

Energy Cost:

Table 5: Energy Cost

	Installed power	Consumption (based on 4100h per year)	Energy Cost for 1 year (130€/MWh)	Overall Energy cost after 15 years Based on Increase of 2% / year
Before	12,77 kW	52.4 MWh	6 810 €	117 775 €
After	2,85 kW	11,7 MWh	1 518 €	26 260 €

$$Installed\ power = \sum installed\ luminaire\ power$$

$$Energy\ saving = (Installed\ power\ before - Installed\ power\ after) * using\ time$$

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

With Energy at 130€ TTC /MWh and 2%of increase / year,

in 15 years (average life time for lighting installation) savings are 91 515 €.

Maintenance Cost:

Table 6: Maintenance Cost

Maintenance	Luminaires with Sodium Lamp*	Luminaires with LED Luminaire*	1 year Maintenance Cost	Overall Maintenance cost after 15 years Based on Increase of 2% / year
Before	73	15	1 609 €	27 825 €
After	0	65	488 €	8 430 €

* 20,5€ TTC / luminaire lamp / year & 7,5€ / luminaire LED / year

After 15 years, Maintenance cost savings are: 19 395 €

After 15 years of exploitation, 611 MWh and 110 910 € are saving. Thus, with this system, energy saving is more than 70%.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4. Implementation of smart lighting concept

4.1 New situation

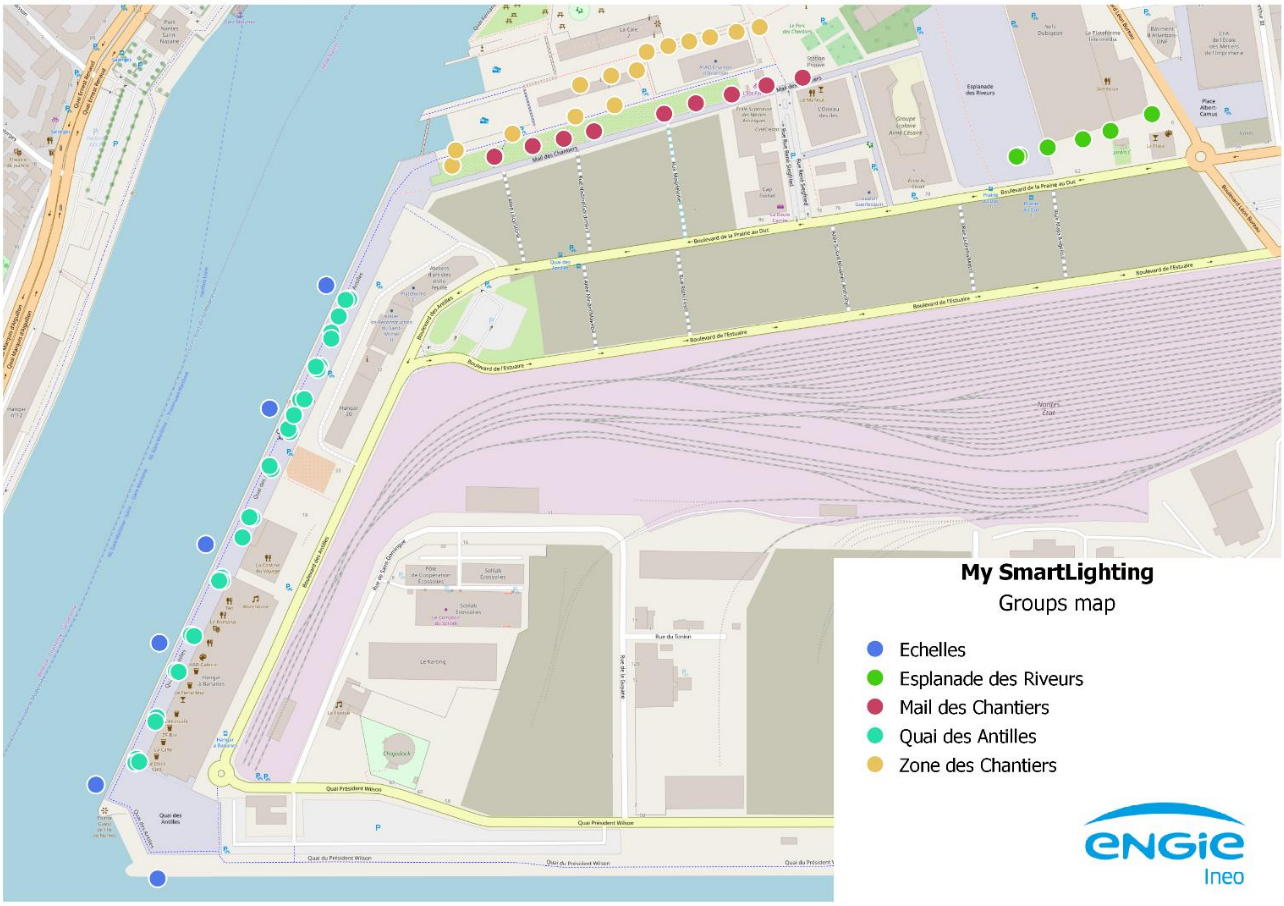

Figure 10: New situation - Plan

4.2 Implementation purpose

As for the design phase, the implementation of smart lighting concepts addresses the same 3 purposes:

- Energy efficiency = the solution should demonstrate energy and CO_2 savings compared to standard
- Interoperability = the solution should demonstrate open data compatibility for easy supervision
- Cost driven = the solution should be affordable compared to standard solution

If those 3 purposes are reached, then the implementation of the solution is widely deployable.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4.3 Technical implementation

Figure 11: Works planning

4.3.1 Works planning

Studies & tests

Each device controller type was tested to identify wiring and commissioning procedure. Failures were generated to test fault detection on the supervision platform. Some parameter values were tested, and the supervision platform was implemented.

Settings

Each device controller was configured individually on the supervision platform to set GPS location, controller type and other data, so that the sensor installation could be done easily and quickly.

Installation

Sensors were installed in existing luminaires and in new ones once changed. A visual check on sensor wiring and the luminaire's ability to turn made sure the controller was working.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

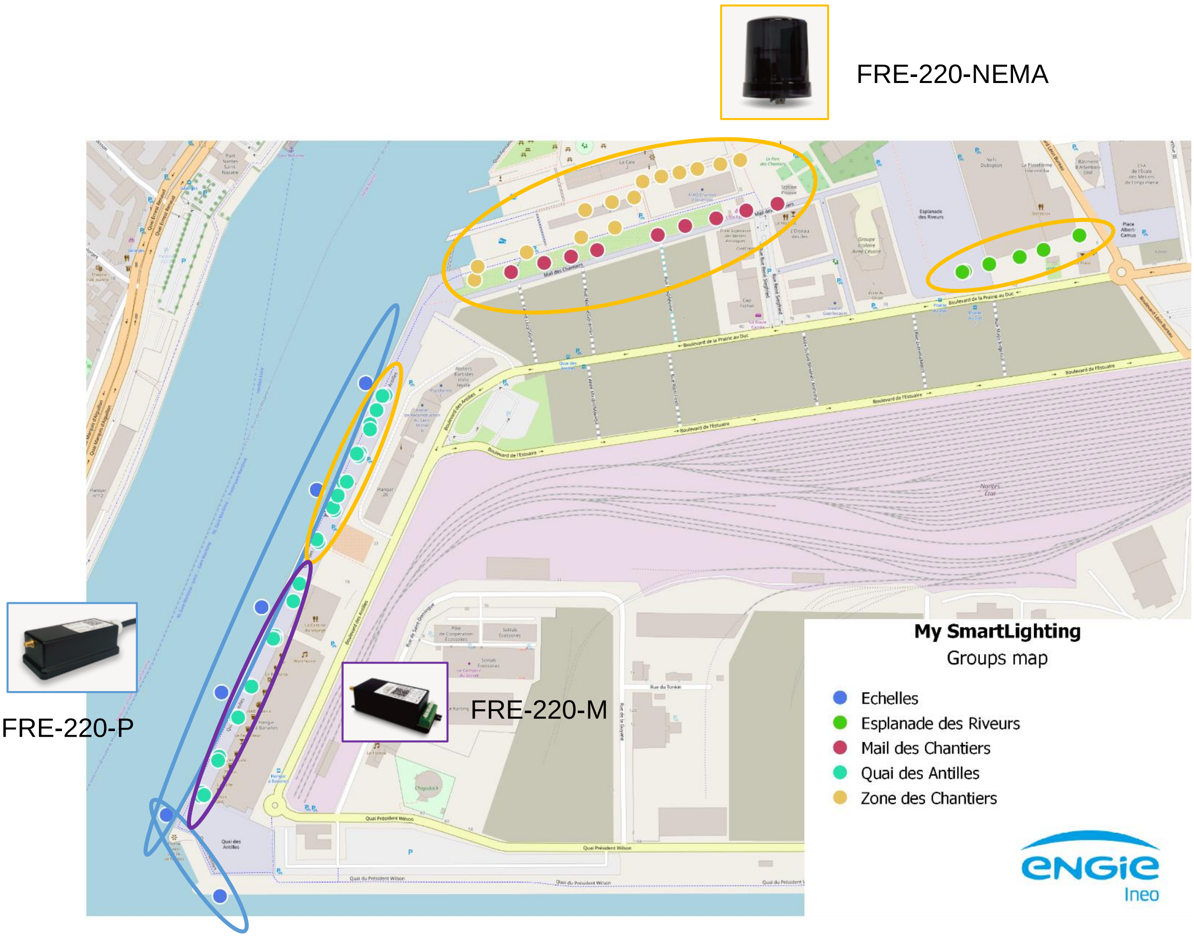

Figure 12: Zoning and Fittings implementation

Table 7: List of Materials

Area	Sensors installed	Controller Type		Luminaire Type
Quai des Antilles	30	15	FRE-220-NEMA	Comatelec NEOS 2 – 48 leds
		15	FRE-220-M	
Mail des Chantiers	9	FRE-220-NEMA		Comatelec NEOS 1 – 24 leds
Zone des Chantiers	14	FRE-220-NEMA		Comatelec NEOS 1 – 16 leds
Esplanade des Riveurs	6	FRE-220-NEMA		Comatelec NEOS 2 – 48 leds
Echelles	6	FRE-220-P		WE-EF FLC121

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4.3.2 Commissioning operations

Device controllers appeared as “commissioned” on the platform once they had sent data to the gateway for the first time.

As luminaires and sensors are powered by the astronomical clock in the electrical cabinet, device controllers appear “Unreachable” during the day and “Online” at night.

4.3.3 KPI Monitoring

Three indicators were defined on this task:

- Energy use for lighting: it will be monitored with the lighting supervision.
- Reduction in annual lighting energy use comparted to initial situation. It will be calculated with this formula:

$$100 - \frac{lighting\ annual\ final\ energy\ consumption\ after\ project\left(\frac{kWh}{year}\right) \bullet 100}{lighting\ annual\ final\ energy\ consumption\ before\ project\left(\frac{kWh}{year}\right)}$$

- Carbon dioxide emission reduction. It will be calculated with this formula:

$$100 - \frac{annualcarbondioxydeemissionafterproject\left(\frac{tonnes}{year}\right) \bullet 100}{annualcarbondioxydeemissionbeforeproject\left(\frac{tonnes}{year}\right)}$$

4.3.4 Lighting use case

As it is shown on the figure 10, different groups of luminaires were made, depending on light management needs. Each zone corresponds a programming scenario described in Table 8 below.

Table 8: Programming Scenarios

Area	Context	Need	Schedule
Quai des Antilles	As the area is highly used, the lights must be powerful.	Failure detection and remote management	No. Switched by the lighting panel.
Mail des Chantiers	It is currently used as a crossing point. As buildings are under construction, lights and noise must not annoy future inhabitants.	Dimming schedule and presence detection	Switched by the lighting panel. **Schedule A :** Dimming at 30% and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

			70% on presence detection
Zone des Chantiers	Lights should make people use this path rather than the “Mail des Chantiers”	Failure detection and remote management	No. Switched by the lighting panel.
Esplanade des Riveurs	Lights must be switched on and off depending on occasional events	Remote management	No. Switched by the lighting panel.
Echelles	Rescue ladders must be enlightened at night	Failure detection and remote management	No. Switched by the lighting panel.

Schedule

For safety reasons, it was decided that power should be swiched on and off directly from the electrical cabinet: luminaires are switched on and off by the astronomical clock in the electrical cabinet which closes and opens the electrical circuit.

Luminaires scheduled with InteliLIGHT system (in the “Mail des Chantiers” area) obey the schedule saved on the device controller memory. As the controller is powered by the same circuit, the electrical cabinet must be switched on to enable the controller scheduling the lighting.

Figure 13 shows an example of dimming schedule programmed on the project:

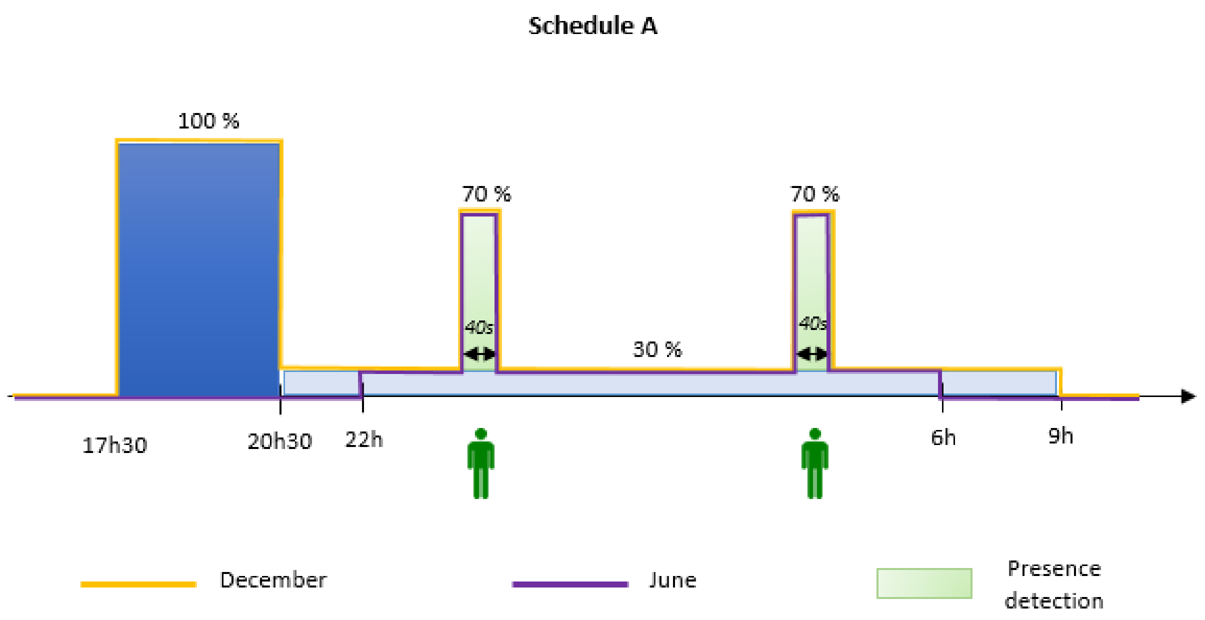

Figure 13: Typical dimming Schedule

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

In this program example, the 100% dimming hours are linked to sunset and limited until 20h30 to not disturb inhabitants. This limitation is programmed using the astronomical clock in electrical cabinet.

In Winter:

From sunset to 20h30, Dimming is 100%.

From 20h30 to sunrise, Dimming is 30% except when the presence of someone is detected, then dimming is 70% on its walking zone.

In Summer:

No use switching on luminaires before 22h00 because of late sunset.

From sunset to sunrise, Dimming is 30% as it is after 20h30 except when the presence of someone is detected, then dimming is 70% on its walking zone.

Real-time remote management

Lights can be switched on and off in real-time from the supervision platform, whether the luminaire is scheduled or not. It can be used for occasional event.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5. Smart lighting concept vs existing solution

5.1 Cost comparison

Table 9: Cost comparison

COST PER YEAR	Investment Cost	Energy Cost	Maintenance Cost	Total cost per year
Initial Situation	7 513 €	6 810 €	1 609 €	8 419€
MSL Solution	1 675,21 €	1 518 €	488€	2 006 €

* 130€ TTC /MWh

** 20,5€ TTC / luminaire lamp / year & 7,5€ TTC/ luminaire LED / year

5.2 Energy Efficiency and CO2 comparison

Table 10: Energy Efficiency / CO2 Comparison

	BEFORE	AFTER
Reduction of energy consumption	52.4 MWh	11.7 MWh
CO2 emitted kg / year *	2462 kg per year	549 kg per year
CO2 saving *	1913 kg per year – 77.8%	

* Based on 47 g per kWh

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5.3 Interoperability comparison

The Smart Lighting concept offers a lot of interoperability with other systems:

- There are different ways to connect the node, so it's possible to adapt it to the existing street light (done for 21 luminaires on this project)The LORA infrastructure created can be used to other connected objects like mobility sensors, environment sensors….
- Other objects can be managed from the Flashnet supervision software
- The Flashnet node can be managed from another supervision platform with an API.

Table 11: List of interoperable Materials

		Manufacturer	Product	Quantity installed
Gateway		KERLINK	LoRa IoT Station	1
		FLASHNET	FRE-220-NEMA	44
Controllers		FLASHNET	FRE-220-M	15
		FLASHNET	FRE-220-P	6

5.4 Replicability

The expectation from this installation is to demonstrate:

- That monitoring Energy consumption allows for better optimisation,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- Dimming the lighting level to the level people need is a way to optimize energy savings without making them feel unsafe
- Supervising the installation allows operators to know in real time when lamps need to be replaced and therefore to increase safety

This experimentation is replicable in mixed-use areas at district level or streets. Smart lighting system is a solution to adapt and adjust lighting to public using and their evolution.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6. Conclusions

ENG commissioned the lighting system in September 2018. With 3 years of operation, ENG and NM will demonstrate the following points in order to prove the interest of replication:

- It is a cost driven solution less expensive than existing solutions on a 15 years maintenance plan
- It will bring 78% of energy and CO_2 emission savings as expected
- Lora Technology is a large network system. Interoperable IoT of traffic management system, bus priority system management, flood detection, etc. could be connected with this network system.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

7. References

Journal Articles Found on a Database or on a Website
Charter for the development and management of public space : http://www.nantesmetropole.fr/pratique/formalites/documents-de-references-relatifs-a-l-amenagement-de-l-espace-public-45462.kjsp

Video of Flashnet system presentation

https://intelilight.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.