Nantes | Hamburg | Helsinki

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D2.18 Baseline report of Nantes demonstration area

WP2, Task 2.1 “Baseline Assessment”

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	D2.18 Baseline report of Nantes demonstration area		
Diss. Level	PU		
Status	Working		
	Verified by other WPs		
	Final version		
Due date	31/05/2020		
Work Package	WP2		
Lead beneficiary	NAN		
Contributing beneficiary(ies)	CAR, CER, TEC, NBK, ENG		
Task description	This task will set and assess, according to WP5, a baseline for Nantes demonstration. Analysis of the district in which the interventions will be implemented with information about the main architectural issues, energy facilities and energy consumption, mobility data and urban infrastructures are necessary for the definition of the baseline and for identifying the improvements potential. More details are needed in the case of the existing urban plans, public procurement and the current citizen engagement strategies in Nantes.		

Date	Version	Author	Comment
06/04/2020	0.1	Pierre Nouaille (CER), Myriam Humlbert (CER)	Definition of the baseline methodology and procedure
16/04/2020	0.2	Pierre Nouaille (CER), Myriam Humlbert (CER) Marine Buron (NAN), Guillaume Chanson (NAN), Benoit Cuvelier (NAN)	Energy interventions baseline integration
07/05/2020	0.3	José L. Hernández (CAR), Rubén García (CAR), Eduardo Miera (TEC), Beatriz Sánchez (TEC)	Feedback in terms of energy interventions and indicators calculation
19/05/2020	0.4	Pierre Nouaille (CER), Myriam Humlbert (CER) Marine Buron (NAN), Guillaume Chanson (NAN), Benoit Cuvelier (NAN)	Completion of the energy and mobility baseline sections
22/05/2020	0.5	Beatriz Sánchez (TEC), José L. Hernández (CAR)	Reviewed version with comments
28/05/2020	0.6	Pierre Nouaille (CER), Myriam Humlbert (CER) Marine Buron (NAN), Guillaume Chanson (NAN), Benoit Cuvelier (NAN)	Version with comments and feedback integrated into the deliverable
31/05/2020	1.0	José L. Hernández (CAR), María Ángeles Gallego (CAR), Fredy Vélez (CAR)	Final checks, comments and edition

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Abbreviations and Acronyms

Acronym	Description
BEST	Building Energy Specification Table
COSTIC	Comité Scientifique et Technique des Industries Climatiques
CV	Cross Validation
DHW	Domestic Hot Water
EDF	Électricité de France
EV	Electrical Vehicles
GHG	GreenHouse Gas
HDD	Heating Degree Days
ICE	Internal Combustion Engine
IPMVP	International Performance Measurement & Verification Protocol
KPI	Key Performance Indicator
LED	Light-Emitting Diode
M&V	Measurement & Verification
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
RES	Renewable Energy Systems
RMSE	Root-Mean-Square Error

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1. Executive Summary

The purpose of this document is to describe the performance of Nantes demonstration actions in building, city infrastructure and mobility sectors before mySMARTLife project activities.

This activity, known as baseline calculation, is implemented by using the common project indicators that have been assigned for the assessment of specific Nantes demonstrative actions in WP5 - Deliverable 5.1: Integrated evaluation procedure. Thus, this document describes the baseline values of these actions, based on the common project indicators, built to provide a reference for comparison in WP5 that will monitor and evaluate the impacts of Nantes demonstration, once all mySMARTLife actions have been deployed.

This report is a complement to the already approved Nantes baseline deliverable D2.1, submitted at M12. That document described the city audit in Nantes as Part I. Now, this document complements this city audit with the baseline values, once the common project indicators became available with the finalisation of D5.1 at M36. Therefore, this report can be considered as Part II of D2.1.

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2. Introduction

2.1 Purpose and target group

This report presents the baseline of the city of Nantes in terms of status of the interventions before the execution of the mySMARTLife actions. In this sense, this document constitutes the second part of the Baseline report of Nantes demonstration area, whereas the City Audit (D2.1), submitted in November 2017, was the first part.

City Audit described the urban context of the Nantes agglomeration and the main issues that Nantes public policies have to face, in terms of energy, urban development, mobility, but also in terms of citizen engagement or development of digital infrastructures and services. It also mentioned the main axis of Nantes public action in all these fields. Finally, City audit characterized situation of the Nantes metropolitan area through city level indicators (defined jointly with the cities of Hamburg and Helsinki).

This second part focuses on the projects and actions implemented in the framework of the mySMARTLife project, in order to contribute to meeting the challenges set out in D2.1. It is therefore the logical continuation of the first part.

This deliverable was originally due by month 12 (November 2017). However, at month 12, the deliverable cannot take into consideration the final detail of all the interventions. Indeed, the deployment of certain actions was encountering difficulties, so that their technical content and implementation modalities were not yet precisely known at that time. Considering that an Amendment was requested in September 2017 (month 10) and that the process of negotiation and approval could still take several months, it was agreed with the Project Officer to submit an interim report at the original due date, month 12, that will include the Nantes City Audit (D2.1). The final version, including the complete Nantes Baseline would be submitted in month 42.

As the second part of the baseline report of Nantes demonstration area, this deliverable focuses on the actions themselves. It aims to describe them in terms of objectives and technical content. In order to allow their evaluation at the end of the project, this part also presents the evaluation indicators selected for each action (indicators defined in the framework of WP5 and more particularly deliverable D5.1) as well as their reference values, before deployment of the actions. The process of collecting and analysing this baseline data was based on a tool developed by CARTIF (and supported by Tecnalia). This tool, common to the 3 cities of the project (Nantes, Hamburg, Helsinki) enabled the consideration of the key issues in following a M&V (measurement and verification) plan.

In order to facilitate reading and understanding of the actions that constitute the Nantes demonstrator, actions have been grouped into different categories:

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- Buildings and districts actions
- Energy city infrastructures actions
- Mobility actions

Thus, in contrast to part I (D2.1), this section only covers actions within the framework of the mySMARTLife project that concern interventions on existing buildings, equipment or infrastructures (or actions that consists in improving an existing situation), for which it is possible to describe the baseline situation. Actions that concern the installation of completely new equipment (such as most of the actions related to the deployment of solar photovoltaic power plants, or the deployment of digital tools) are not addressed in this part, since they cannot be described in terms of baseline situation.

Hence, this second part of the deliverable describes the precise context and technical content of the actions that are being implemented within the mySMARTLife project. It also contains the values of the KPIs that characterize the initial situation before the actions are deployed. These data will serve as a basis for the evaluation of the impacts of these actions, which will be conducted in the framework of WP5.

2.2 Contributions of partners

The following Table 1 depicts the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution of partners

Participant short name	Contributions
CAR	Overall content to sections 1 and 2. Overall review and KPI tool.
TEC	Support for the deliverable and review.
CER	Main contributor of the deliverable, as well as definition of the baseline methodologies.
NAN	Provision of data, indicators and documents.
ENG	Provision of data, indicators and documents.
NBK	Support in the development of the simulation models.

2.3 Relation to other activities in the project

The following Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the mySMARTLife project and that should be considered along with this document for further understanding of its contents.

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Table 2: Relation to other activities in the project

Deliverable Number	Contributions
D5.1	This deliverable provides the overall description of the evaluation framework, and the selection of indicators at city and project level.
D5.5	D2.18 serves as input for D5.5 where the impacts will be evaluated in contrast to baseline.
D2.1	As stated, this is the Part I including the city audit.
D2.3	This deliverable provides information and technical data on action related to the energy renovation of condominium buildings.
D2.4	This deliverable provides information and technical data on action related to the energy renovation of single family houses.
D2.6	This deliverable provides information and technical data on action related to the implementation of digital boilers in buildings.
D2.13	This deliverable provides information and technical data on actions related to electric mobility (e-buses, charging stations, autonomous shuttle)
D2.15	This deliverable provides information and technical data on action related to smart public lighting.

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3. Baseline overview

As stated before, the first part of this task provided an overview of the context in which the Nantes actions to be implemented within the mySMARTLife project are taking place. More in particular, the aforementioned first part deals with a city audit where the city as a whole is analysed.

On the contrary, this second part focuses on the actions themselves and aims to describe them in terms of objectives and technical content. A baseline is considered as the initial situation of the project, or more precisely, to the situation before the project's actions have been implemented.

The reasoning for the baseline need is the calculation of the energy savings. As illustrated in Figure 1, these are obtained during the period after the implementation of the actions. By means of comparing the real data obtained during this period with the "hypothetical" energy use of the baseline during post-retrofitting period. That is to say, translation of the baseline evaluation to the reporting period, which is named as adjusted baseline (baseline adjusted by the new parameters, e.g. climate conditions). Thus, energy savings (or namely avoided energy use) are obtained as,

$$Energy\ savings = Adjusted\ baseline - measured\ energy\ use$$

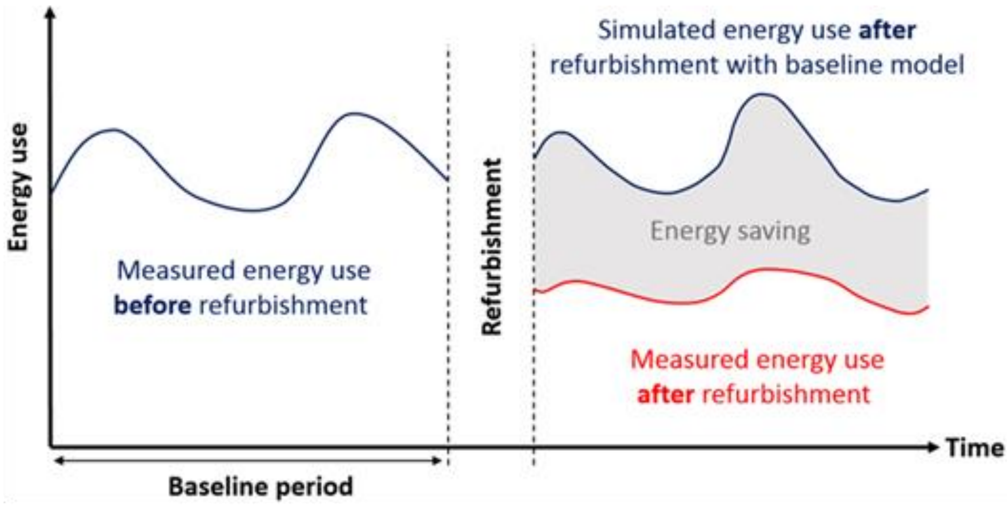

Figure 1: Energy savings definition by IPMVP

Nevertheless, to carry out a proper baseline calculation, the definition of the boundary is crucial. In this sense, two level boundary has been defined in WP5, as illustrated in Figure 2. These boundaries are:

- Building actions, where the objective is to evaluate the reduction in the energy demand by the retrofitting activities, as well as the increase of renewables in the generation / distribution. Therefore, the boundary considers the energy flow that is entering into the building.

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- City infrastructures, where the objective is to analyse the impact in terms of generation elements and how these are incrementing the renewable energy production. Therefore, the boundary, in this case, considers these generation systems, while the buildings would be considered as an energy load.

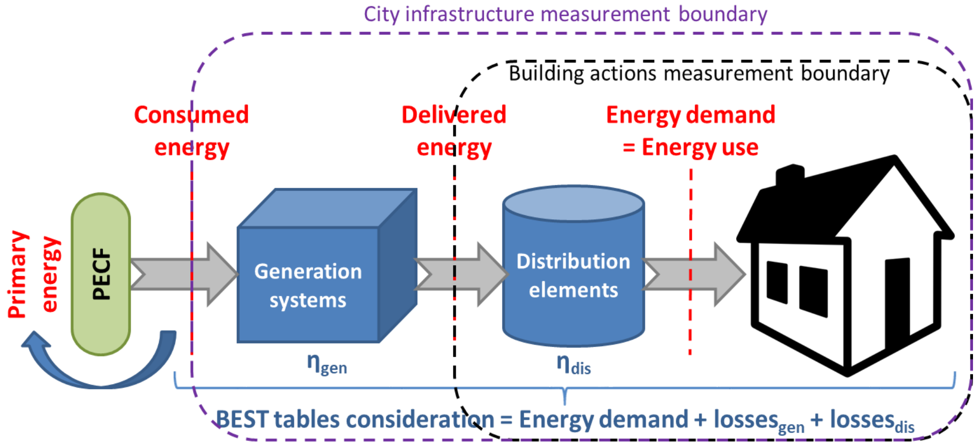

Figure 2: Measurement boundary definition

It should be noted this procedure is followed in energy context. Mobility is easier, where boundaries are not applicable and the baseline, at high-level, represents the CO_2 emissions emitted by conventional vehicles (diesel, gasoline…) that are substituted by electrical vehicles.

Having said that, the baseline reference period is selected according to the available data (e.g. climate conditions) to determine the "current" conditions (i.e. before mySMARTLife). Then, the baseline is considered as a reference year before the implementation of the actions. Along this year, the KPIs defined in D5.1 for each intervention, which comprises a set of related actions, following similar approach than BEST tables (e.g. Pierre Landais interventions include the new construction plus the digital boiler and district heating connection).

In this way, an Excel sheet has been used as support tool for the baseline methodology, as well as calculation of the indicators for the reference year. This Excel guides the cities at time of selecting the proper procedure (real data or simulation), protocol (e.g. IPMVP), selection of boundary (a sample of building, all the district) and parameters useful for the adjustments (e.g. Heating Degree Days).

Moreover, as stated before, the Excel sheet allows the automatic calculation of KPIs based on some basic data, such as thermal / electrical energy consumption. The example for Pierre Landais is illustrated in Figure 3, which includes actions A4, A7 and A17.

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City	Intervention	Indicator	Baseline M1 kWh/month	Baseline M1 kWh/month (m2)
Nantes	Pierre Landais (A4, A7, A17)	E1) Thermal energy consumption		#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E2) Electrical energy consumption		#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E4) Annual energy consumption	0	#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E6) Energy use for heating		#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E7) Energy use for DHW		#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E13) Total renewable thermal energy production		#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E14) Total renewable electrical energy production		#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E15) Total renewable energy production	0	#¡DIV/0!
Nantes	Multi-owner buildings retrofitting (A2, A17)	E17) Degree of energy self-supply by RES	#¡DIV/0!	#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E24) Recovery		#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E26)Degree of heating supply by district heating		#¡DIV/0!
City	Intervention	Indicator	Baseline M1 kWh/month	Baseline M1 kWh/month (m2)
Nantes	Pierre Landais (A4, A7, A17)	E19) Primary thermal energy consumption	0	#¡DIV/0!
Nantes	Pierre Landais (A4, A7, A17)	E20) Primary electrical energy consumption	0	#¡DIV/0!

Figure 3: Excel sheet template for KPI calculation

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4. Buildings and districts actions

4.1 Baseline calculation procedure

As it was explained in the previous section, the scope of the baseline is the creation of a reference model that allows the adjustments during post-intervention in order to determine the energy savings. In this sense, IPMVP is selected as the reference protocol to apply the baseline calculation, which consists of 10 steps:

1. Objective of the action (included in the DoA and summarised in each section for the interventions).
2. Selection of the IPMVP action. In this sense, IPMVP offers 4 possibilities as follows:
    a. IMPVP Option A: Isolated system with a key parameter (e.g. performance of a new boiler)
    b. IMPVP Option B: Isolated system measuring all the parameters (e.g. all data-points from a new boiler)
    c. IPMVP Option C: Whole facility with monitored data (e.g. boiler + building + final energy use…)
    d. IPMVP Option D: Whole facility with simulated data (baseline through simulation tools, but assessment with real data)
3. Selection of the baseline period (done in each one of the actions depending on its own life cycle).
4. Reporting period selection that starts just after the implementation of the intervention and ends at the end of mySMARTLife.
5. Adjustment parameters, which are included in the next chapters (e.g. HDD).
6. Analysis procedure, also explained, i.e. simulation, data… Nevertheless, the reporting period will be always based on real-data as a mySMARTLife project requirement.
7. Energy prices for the cost analysis. This is out of the scope of this deliverable and it will be evaluated from the economic pillar perspective within WP5.
8. Measurement specifications, which could be checked in the project description (DoA, web site…).
9. Monitoring responsible, but, this is being dealt in WP5.
10. Expected accuracy, which will be treated in the D5.5 when the impact assessment will be analysed.

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To that end, the tool developed by CARTIF (and supported by Tecnalia) guides the cities in this selection. Figure 4 guides the selection of the procedure, based on data, simulation or others, while, in the case of data, determine the type of data (sensors, bills…). Moreover, the tool also offers the explanation of the option to be selected following the previous explanations.

Calculation procedure to be used	
Data-driven (KPIs)	Yes or No
Simulation tools (e.g. TRNSYS, Energy+...)	Yes or No
Others	To be detailed

Data source for the baseline calculation	
Bills	Yes or No
Sensor data	Yes or No
Others	To be detailed

Figure 4: Calculation procedure selection

Also, the tool supports the definition of the boundary, where the level to be covered, its area and sample size are set. When a subset of building is selected, the extrapolation method is also explained. Also, the baseline period selection, as Figure 6.

Measurement boundary	
Level (Energy System, Dwelling, Building, District)	
Total area covered by the boundary (m2)	
Sample size for the baseline (m2)	
Aggregation/extrapolation methods when sample size is not the same than total area (e.g. simulation of 1 building out of 10)	
Selected dwellings (number, which ones)	
Selected buildings (number, which ones)	

Figure 5: Selection of the boundary

Baseline period	
Baseline period (required)	1 Full year
Baseline period (defined)	Start date (from which month/year)
	Final date (until which month/year)

Figure 6: Baseline period selection

Finally, the description of the parameters that affect the adjustments, such as Figure 7.

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Parameters	
Heating Degree Days (HDD)	M1:
	M2:
	M3:
	M4:
	M5:
	M6:
	M7:
	M8:
	M9:
	M10:
	M11:
	M12:
Other parameters (affecting baseline)	e.g. radiation
	e.g. occupancy

Figure 7: Parameters for adjustments

In this way, as a summary, the procedure is based on the 10 steps of IPMVP, which are supported by the tool to calculate the KPIs. This provides guidance for the cities at time of implementing the measurement and verification plans. The details of how this procedure is applied in the different interventions are shown in the next chapters.

4.2 Overview of the actions

As mentioned in the city audit (Part I), the residential sector is, in Nantes, the second most energy-consuming sector and the second most CO_2-emitting sector (32% of the territory's emissions). The number of old housing units to be renovated as a priority is 116,000, i.e. approximately 1/3 of the total housing stock in the Nantes conurbation. They have been built before the 1st French energy saving regulation (1974) and are the most energy-consuming dwellings. They are split in equivalent proportions of single-family houses and apartments.

They are a priority target of Nantes' public policies in terms of reducing consumption and GHG emissions in the residential sector. The new Climate Plan, adopted in February 2018, sets up the objective to invest 100 million euros from the metropolis by 2030, in order to carry out energy renovation of 10,000 private housings units.

Therefore, as part of the mySMARTLife project, several actions have been undertaken in order to experiment different technical and financial solutions for the energy renovation of single-family homes and condominiums (**actions 2 and 3**). In addition, actions have also focused on the installation of innovative energy production systems (photovoltaic panels, hybrid solar panels, digital boilers, etc.) on existing or new buildings (**actions 7, 8 and 12**).

And even if the renovation of the old housing stock (especially private housing) is the main lever for reducing energy consumption and emissions in the residential sector, the strong demographic

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attractiveness of Nantes also makes it necessary to think about exemplary new buildings in terms of energy performance. In this respect, some actions of the mySMARTLife project consist in monitoring the energy performance of new buildings aiming at high performance levels, higher than the national regulations (**actions 1, 4 and 5**).

4.3 Retrofitting of multi-owner residential buildings (action 2) and connection of two of them to district heating (action 17)

4.3.1 Description of the action

As part of mySMARTLife project, six buildings have been selected as demonstrative action for thermal retrofitting of co-ownership buildings.

These six buildings have conducted high level energy retrofitting works that represent around 17,000 m² and 200 dwellings (action 2). The co-owners of these buildings had accepted the works to achieve a high-performance renovation, and the works are achieved by the end 2019. Two of them (Nantes-Paris A and Nantes-Paris B buildings) are also connected to the high-performance and mainly-based on RES district heating in Ile de Nantes, as part of the action 17[1].

Generic information about these six buildings is described in Table 3 and some pictures in Figure 8.

The action 2, its buildings and the monitoring are described more precisely in Deliverable D2.3 High level energy retrofitting of multi owner private buildings.

Table 3: Selected buildings for mySMARTLife

Name	Number of flats	Gross area	Construction year	Initial space heating source	Initial DHW heating source	Cost of the work	End of work
Nantes-Paris	A: 71 B: 39	A: 6,550 m² B: 3,198 m²	1962	Gas (collective)	Gas or electricity (individual)	2,239,949 €	05/2018
Benoni-Goulin	76	5,693 m²	1958	Gas (collective)		1,580,306 €	12/2019
Le Strogoff	36	2,225 m²	1971	Gas (collective)	Gas (collective)	468,795 €	03/2018
Val de Loire	20	1,441 m²	1976	Gas (individual)	Gas (individual)	983,000 €	10/2018
Massillon	34	2,889 m²	1972	Gas (collective)		1,166,259 €	06/2019

[1] In the Strogoff building, solar panels have also been installed.

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Nantes-Paris (before retrofitting)

Benoni-Goulin (during retrofitting)

Massillon (before retrofitting)

Le Strogoff (before retrofitting)

Val de Loire (after retrofitting)

Figure 8: Examples of the retrofitted multi-owner buildings

4.3.2 KPIs

In these six buildings, assessment will focus on measuring the energy consumption saved by the retrofitting. The chosen method falls under Option C of the IPMVP protocol. The energy consumption concerned is the monthly space heating and Domestic Hot Water energy consumption of the whole building, when the production is collective or of 15% flats when production is individual. The monthly electricity consumption of common spaces and the monthly private electricity consumption of 15% of flats are also monitored and will be compared to normal practise. The boundary of energy consumption concerned is precised for each building in 4.3.3.

In relation with D5.1 Integrated evaluation procedure, KPIs have been defined to evaluate these actions and their impacts (cf. Table 4):

- Reduction in annual heating and in DHW are deduced from the monitoring (cf. 4.3.3)
- CO_2 emissions will be calculated for each building by considering emissions due to private and common electricity consumption, and gas consumption for space heating and Domestic Hot Water consumption.
- District heating is monitored for Building A and B of Nantes-Paris and renewable thermal energy production on Le Strogoff, to deduce the renewable energy production, and the % of supply for the concerned build

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The parameters used to deduce CO_2 emissions and primary energy from the monitored final energy are presented in Table 5.

Table 4: KPIs for actions 2 and 17

Ref. indicator	Indicator	Unit	Formula
E29	Total greenhouse gas emissions (electrical)	kg CO_2eq/(m².month); kg CO_2eq/(m².year)	E2 * electrical energy emission factor
E31	Total greenhouse gas emissions	kg CO_2eq /(m².month); kg CO_2eq /(m².year)	E28 + E29
E25	Total heat supplied to the buildings connected to district heating network	kWh/year	
E26	Degree of heating supply by district heating	% of kWh/year	(E25 * 100) / E4
E13	Total renewable thermal energy production	kWh/year or kWh/(m².year)	#
E14	Total renewable electrical energy production	kWh/year or kWh/(m².year)	#
E15	Total renewable energy production	kWh/year or kWh/(m².year)	E13 + E14
E17	Degree of energy self - supply by RES	% of kWh/year	(E15 * 100) / E4
E5	Reduction in annual energy consumption	% in kWh	100 - [(E4 after) * 100 / (E4 before)]
E10	Reduction in annual heating energy demand ambitious compared to national regulation for new or retrofit building	kWh/(m².year)	100 - [(E6 * 100) / (national regulation)]
E11	Reduction in annual DHW energy demand ambitious compared to national regulation of retrofitted building and/or normal practise	kWh/(m².year)	100 - [(E7 * 100) / (national regulation)]
E22	Reduction of total primary energy consumption	% change in kWh/(m².year)	100 - [(E21 after * 100) / (E21 before)]
E32	Reduction of total greenhouse gas emissions	% change in kg CO_2eq/(m².year)	100 - [(E31 after * 100) / (E31 before)]
E16	Increase in local renewable energy production	% of kWh/year	[(E15 after * 100) / (E15 before)] - 100
E18	Increase of degree of energy self - supply by RES	% of kWh/year	[(E17 after * 100) / (E17 before)] - 100

Table 5: Parameters used for calculation of KPI's

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Parameter	Value	Reference
Emission factor of the French electricity grid (kg CO_2 eq / kWh)	0.093	Covenant of Mayors 2013-17
Emission factor of the French electricity grid in 2018 (kg CO_2 eq / kWh)	0.0571	Base carbone Ademe – 2018-20
Emission factor of the French electricity grid in 2015 (kg CO_2 eq / kWh PCI)	0.227	Base carbone Ademe – 2015-20
Emission factor of the French electricity grid in 2015 (kg CO_2 eq / kWh PCS)	0.205	Base carbone Ademe – 2015-20
Emission factor of the French gas mix (kg CO_2 eq / kWh)	0.227	Base carbone Ademe – 2015-20
Emission factor of wood (kg CO_2 eq / kWh)	0.0295	
Emission factor of district heating (kg CO_2 / kwh)	0.042	http://reseaux-chaleur.cerema.fr/contenus-co2-des-reseaux-de-chaleur-et-de-froid-arrete-du-11-avril-2018
Emission factor for thermal solar energy (kg CO_2 eq/ kWh)	0.013	http://www.bilans-ges.ademe.fr/documentation/UPLOAD_DOC_FR/index.htm?renouvelable.htm
Primary factor for electricity	2.58	RT 2012
Primary factor for renewable energy sources	0.66	
Primary factor for other energy sources	1	
Primary factor for the district heating	0.7144	http://reseaux-chaleur.cerema.fr/contenus-co2-des-reseaux-de-chaleur-et-de-froid-arrete-du-11-avril-2018

4.3.3 Methodology for evaluation

As the six buildings were chosen for the mySMARTLife project during the works, there is no precise monitoring before refurbishment. We only could collect annual consumption from bills and audits. On the contrary, monitoring after refurbishment will provide accurate energy consumptions on these six renovated buildings.

Therefore, the methodology proposed is based on the creation of a model during the reporting period, and not on a model before refurbishment, and the comparison will be post-ante.

The reported energy consumption data will be adjusted by taking into account meteorological conditions (especially external temperatures[2]) thanks to monthly heating degree days that will also be collected

[2] If regression parameters $R^2 < 0,80$ and CV(RMSE) < 15%

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during all the monitoring period. If relevant[3], the energy consumption will also be adjusted by occupancy conditions (internal temperature, number of occupants, water consumption in m^3) and solar irradiation.

Indeed, these sets of data will be used to build up a model for the monthly energy consumption of each of the six renovated buildings using the methodology described in option C of International Performance Measurement and Verification Protocol (IPMVP). These seven models will characterize the behaviour of each renovated building in terms of energy consumptions according to the meteorological conditions, and other relevant factor.

On the other hand, historical monthly meteorological data, related to periods before renovation works have been collected. They are presented in the table below.

Table 6: Monthly heating degree days in Nantes[4]

Month	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
September	96	53	84	59	42	89	43
October	175	132	146	102	102	171	183
November	300	168	269	276	194	167	266
December	478	287	303	341	338	241	359
January	380	335	377	301	358	319	427
February	269	424	362	267	348	301	269
March	256	228	337	260	276	311	220
April	123	250	241	170	157	242	215
May	98	120	179	135	133	124	91
June	66	62	74	52	56	52	45
July	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0
Yearly value	2241	2059	2372	1963	2004	2017	2118

These meteorological data will be used as inputs of the models of the six renovated buildings, in order to estimate the theoretical energy consumption of the renovated buildings in similar weather conditions.

The monthly energy consumption for heating and Domestic Hot Water (DHW) can be expressed in function of monthly Heating Degree Days (HDD), with following equation:

$$\text{Consumption} = a\ HDD + b$$

With a and b specific to each building.

[3] If regression parameters $R^2 < 0,80$ and CV(RMSE) < 15%

[4] Reference : COSTIC ; référence value = 18°C, météorologique station = Nantes

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For some buildings, it will be necessary to take into account other factors to obtain a relevant model (with regression coefficient $R^2<0.80$ and CV(RMSE)<15%), as mean internal temperature (Tint) or monthly irradiation (Ir), or Nocc (number of occupant) for instance :

Consumption = a x HDD+ b x Tint+c x Ir +d x Nocc + e

As stated before, these estimations (model created during the reporting period) will be compared to the baseline values, which correspond to the real consumptions of the buildings before renovation, obtained through energy bills (cf. 4.3.4).

The energy saving for one year can then be evaluated with following equation:

Saving = Consumption_adjusted – Baseline_value = Σyear (a HDD_baseline_period+ b)– baseline value

Or with more factors:

Saving = Consumption_adjusted – Baseline_value = Σyear (a HDD_baseline_period+ b x Tint baseline_peridod + c x Ir_baseline_period + d x Nocc_baseline_period + e) – Baseline_value

For Massillon and Le Strogoff Buildings, the model will be built for the energy consumption of Domestic Hot Water (which mostly depends on the number of occupants and the cold water temperature) and space heating.

For Nantes Paris (Building A and B) and for Benoni Goulin Building, the model will be built for the energy consumption of space heating only: indeed, these three buildings have individual Hot water preparation, that was not monitored and for which there is no baseline value. Nevertheless, the consumption for DHW of 15% of the flats is monitored after refurbishment and will be compared to normal practise (Best tables). The DHW energy consumption will be extrapolated to the whole building according flat's typology.

For Val de Loire Building, as space heating and DHW preparation is individual. For this reason and due to the monitoring sample of 25% of the apartments within this building, one model will be built for each of the five flats that are monitored. By extrapolation techniques, a global model for the whole building will be obtained so that the building performance could be analysed and compared during the post-intervention. It will be done according to the heat loss area of flats and the DHW consumption, as well as the flat's typology.

The specific electricity consumption of the buildings will be compared directly to baseline values. Electricity consumptions for common areas are monitored and specific electricity consumption is monitored for 15% of the flats. The specific electricity consumption of the monitored flats will be extrapolated to the whole building according flat's typology.

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4.3.4 Baseline and reference values for evaluation

From the energy audits provided, we have annual heating consumption data for the buildings of Nantes-Paris, Benoni Goulin, Le Strogoff and Massillon (at least three heating seasons).

The electricity consumption, for common area, is available for Massillon and Strogoff buildings only. For the other buildings, the electricity consumption for common area, monitored after refurbishment, will be compared to normal practise (Best tables).

The hot water consumption is available Massillon and Strogoff only. The hot water preparation for Nantes-Paris (Building A and B) and Benoni Goulin is individual and was not renovated. For these buildings, the consumption for DHW monitored after refurbishment will be compared to normal practise (Best tables).

Table 7: Baseline values for Nantes-Paris building

Indicator	Unit	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012
Annual energy consumption for heating (gas)	kWh	1,072,000	1,208,000	1,104,000	990,000	
Annual electricity consumption for common areas	kWh					34,000

Table 8: Baseline values for Benoni-Goulin building

Indicator	Unit	2009/2010	2010/2011	2011/2012	2012/2013
Annual energy consumption for heating (gas)	kWh	982,853	886,820	838,928	993,772
Annual electricity consumption for common areas	kWh			12,249	12,138

Table 9: Baseline values for Le Strogoff building

Indicator	Unit	2011	2012	2013
Annual energy consumption for heating and DHW (gas)	kWh	498,000	448,000	461,000

NB: before renovation DHW and space heating consumption are not separately collected.

Table 10: Baseline values for Massillon building

Indicator	Unit	2013	2014	2015
Annual energy consumption for heating (gas)	kWh	412,000	394,000	352,000
Annual electricity consumption for common areas	kWh	26,243	22,099	24,541
Annual gas consumption for domestic hot water	kWh	77,000	69,000	77,000

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For Val de Loire, as the space heating and hot water preparation is done by individual boilers, we have only the global gas consumption (hot water and space heating), collected with bills on 15% of the total flats (i.e. 3 apartments).

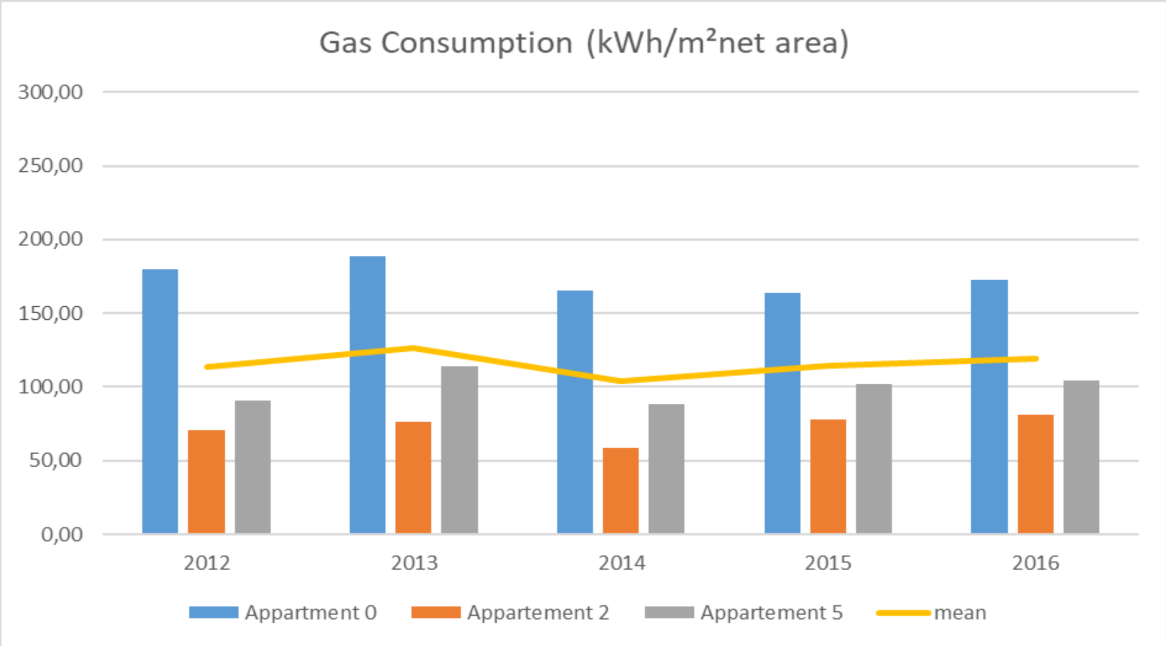

Figure 9: Baseline values for Val de Loire building

In Figure 9, the annual gas consumption collected for the 3 during flats five years is reported. Then, the gas consumption on whole building was extrapolated according to the net area. Other extrapolation were tested (according heat loss area) but led to more dispersion between the two flats with 1 occupant.

You can notice that Apartment 0 consumption is almost twice the two others, but it comes from the Domestic Hot Water consumption, as there are 2 occupant in Apartment 0, while only one in the others.

There is no data for specific electricity consumption of the flats before renovation: the monitored consumption after refurbishment will be compared to normal practise (BEST tables).

In addition to the previous figures, Table 11 specifies the calculated energy demand (kWh/m²year) before works and energy demand expected after retrofitting for each building, both calculated according Th-CE-ex calculation code of French energy saving regulation / Th-ex for existing buildings and reported in their BEST tables.

The expected energy demand results for the retrofitting specifications is also compared to normal practices. As explained in D2.3 High level energy retrofitting of multi owner private buildings, for the renovation of buildings, there is no compulsory minimum energy demand: the French regulation requires only minimum performances for each renovated building fabric element. But we used the reference

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building specification defined in the French regulation of deep energy retrofitting of existing buildings, and the consumptions for the reference building were calculated thanks to the Th-CE ex code.

We obtained for normal practice/national regulation a heating and DHW consumption each of 50 KWh/m²yr, for lighting consumption 10 KWh/m²yr.

The improvement in comparison to normal practice/regulation varies from 35% to 68% depending on the building, its insulation level and its use of RES.

This normal practise value will be used for comparison, if no data was monitored before refurbishment. The % saving value obtained by monitoring will be compared to the % saving goal of the BEST tables, after adjustment of the model to the meteorological and occupancy conditions of French regulation code.

Table 11: Energy demand of buildings (final energy) according to the normal practices and status before works

Name of the building	Energy demand (kWh / m²)				RES contribution (kWh/m²year)		Total building energy use (kWh/m²year)	
	Before works	Normal practice	Refurbishment specifications	Improvement	Refurbishment specifications	Improvement	Refurbishment specifications	Improvement / normal practice (%)
Nantes-Paris A	110	125	57	68	17	17	40	68%
Nantes-Paris B	158	125	62	63	18	18	44	65%
Benoni-Goulin	232	121	58	63	0	0	58	52%
Le Strogoff	230	124	83	41	10	10	73	40%
Val de Loire	164	124	73	51	0	0	73	41%
Massillon	178	123	80	43	0	0	80	35%

4.3.5 Additional description, of the adjustments conditions for baseline period

For all buildings: monthly irradiation of Nantes (Restcreen/ satellite data)

Nantes Paris

Internal temperature: 20°C (measured on a sample of dwellings)

No cold water consumption: individual production

Benoni Goulin

Internal temperature:

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Set temperature	18	19	20	21	22
%	16.66	16.66	16.66	33.33	16.66

Year	2012	2013	2014
Water consumption (m3/year)	4,070	3,753	3,902

Massillon:

Internal temperature: 20.9°C (measured on a sample of dwellings)

Total number of occupant: 52 (estimation from survey)

Year	2013	2014	2015
Total water consumption (m3/year)	929	1003	997
Domestic Hot Water (m3/year)	622	505	615

Le Strogoff

Internal temperature: 21.1°C (measured on a sample of dwellings)

Total number of occupant: 54 (estimation from survey)

Year	2011	2012	2013
Total water consumption (m3/year)	1,183	1,179	1,035
Domestic Hot Water (m3/year)	652	585	561

Val de Loire

Number of occupants before refurbishment: Apartment 0: 2, Apartment 2: 1, Apartment 5: 1.

4.4 Retrofitting of individual houses (actions 3 and 12)

4.4.1 Description of the action

Nantes Métropole has approximately 133,000 single-family homes. Their energy renovation is a real challenge, insofar as surveys[5] realized in France underline that retrofitting operations implemented in individual houses are not often very good in terms of energy savings. Indeed, only 25% of retrofitting operations enable to significantly increase energy performance of houses. One of the reasons is that an

[5] Ademe, 2018, Enquête Tremi – travaux de rénovation énergétique des maisons individuelles – campagne 2017, 32 p. https://www.ademe.fr/sites/default/files/assets/documents/enquete-tremi-2017-010422.pdf

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effective retrofitting operation often requires an overall renovation of the building and a good level of performance for each works package engaged.

The "energy retrofitting in individual houses" action of mySMARTLife project (**action 3**) is carried out by Engie. The action aims at testing a complete approach for energy retrofitting that makes it possible to transform a very energy intensive house to effective house, at the BBC-level standard[6]. To do this, the project consists on completing works packages among the classical ones realized for energy retrofitting of buildings (insulation of walls and roofs, installation of new windows or new heating systems…) on 1 individual house, whose owner has been selected through a call for candidates. In addition, Engie will install hybrid solar panels from the Systovi company, to produce both electricity (for self-consumption) and to blow hot air in house (aero-voltaic system) (**action 12**). In this way, the project carried out by Engie tries to demonstrate the relevance of complete energy renovation operations in one individual house, combining works for energy retrofitting and installation of renewable energy production systems.

In addition to this heavy renovation operation, Engie will also carry out partial renovation of 32 other houses.

The Engie project, however, goes beyond the mere implementation of technical solutions for the energy renovation of housing. By leading the preliminary thermal studies, ensuring the realization and coordination of the works, and accompanying owners in the whole of their approach of renovation (constitution of documents to get building permits, help for funding's search), the project brings to owners an "integrated offer". This helps to remove the main obstacles and difficulties usually encountered by owners wishing to undertake a major renovation of their home.

Figure 10: Picture of the house before works

[6] For more details about this action, see D2.4.

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4.4.2 KPIs, methodology and baseline values for evaluation

The evaluation process of this action aims at measuring the energy savings due to the works carried out in these 32 houses. As works mainly consisted in reducing energy consumptions for thermal needs, evaluation will mainly focus on comparing energy consumptions for heating and domestic hot water before and after works (for each of the 32 houses), taking into account climatic conditions (heating degree days). In this way, KPIs that will be used for evaluation are mentioned in the table below. They have been defined within “D5.1 Integrated evaluation procedure”.

Table 12: KPIs related to the action

Ref. indicator	Indicator	Unit
E1	Final thermal energy consumption	kWh / m².year
E2	Final electrical energy consumption	kWh / m².year
E4	Final energy consumption	kWh / m².year
E5	Reduction in annual energy consumption	%
E6	Energy use for eating	-
E7	Energy use for DHW	-
E10	Reduction in annual heating energy use ambitious compared to initial situation	%
E13	Total renewable thermal energy production	kWh / year
E14	Total renewable electrical energy production	kWh / year
E15	Total renewable energy production	kWh / year
E19	Primary thermal energy consumption	kWh / m².year
E20	Primary electrical energy consumption	kWh / m².year
E21	Primary energy consumption	kWh / m².year
E22	Reduction of total primary energy consumption	%
E28	Total greenhouse gas emissions (thermal)	Kg CO_2 eq / year
E29	Total electrical greenhouse gas emissions	Kg CO_2 eq / year
E31	Total greenhouse gas emissions	kg CO_2 eq/(m^2.month); kg CO_2 eq/(m^2.year)
E32	Reduction of total greenhouse gas emissions	%

Consumption data before and after work will be obtained mainly via the owners' bills[7], which will provide information on actual energy consumptions.

In order to limit the inconvenience for the owners related to the visits that this method of collection requires, all this data will be recovered in one go, 1 year after the end of the work, as part of the monitoring process.

However, for 16 of the 32 houses, we already have additional data from the thermal studies realized before the work was carried out.

[7] Only the electricity consumption data of the house equipped with hybrid panels will be retrieved from the meter.

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These diagnostics were carried out by different engineering and design companies, with the aim of carrying out retrofitting work that is very different from one house to another. This explains why, in some cases, certain data, such as electrical consumption (other than for heating or DHW) are missing. These data give a first idea of the level of energy performance of houses before construction (often mediocre). They do not constitute baseline data as such, but may nevertheless help in the analysis of the impacts of the renovation during the evaluation procedure.

Table 13: Characterization of the energy performance of 16 houses before work (data from thermal diagnostics)

Ref. ind.	Indicator	Unit	Home 1	Home 2	Home 3	Home 4	Home 5	Home 6	Home 7	Home 8
-	Surface area	m²	144	140	100	114	116	70	63	250
E1	Final thermal energy consumption	kWh / m².year	123	42	182	127	250	127	269	113
E2	Final electrical energy consumption	kWh / m².year	-	83	37	-	34	158	-	21
E4	Final energy consumption	kWh / m².year	123	83	219	127	291	158	269	134
-	Energy source for heating	-	Natural gas	Elect. (heat pump)	Natural gas	Natural gas	Natural gas	Elect.	Natural gas	Natural gas
E6	Final energy use for heating	kWh / m².year	101	19	132	101	223	69	237	94
-	Final energy source for DHW	-	Natural gas	Elect.	Natural gas	Natural gas	Natural gas	Elect.	Natural gas	Natural gas
E7	Energy use for DHW	kWh / m².year	22	23	51	26	27	58	32	19
E13	Total renewable thermal energy production	kWh / year	0	0	0	0	0	0	0	0
E14	Total renewable electrical energy production	kWh / year	0	0	0	0	0	0	0	0
E15	Total renewable energy production	kWh / year	0	0	0	0	0	0	0	0
E19	Primary thermal energy consumption	kWh / m².year	123	109	182	127	250	328	269	113
E20	Primary electrical energy consumption	kWh / m².year	-	215	95	-	88	407	-	54
E21	Primary energy consumption	kWh / m².year	123	215	278	127	345	407	269	167
E28	Total greenhouse gas emissions (thermal)	Kg CO_2 eq / year	3643	336	3739	2982	5934	508	3458	5775

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E29	Total electrical greenhouse gas emissions	Kg CO_2 eq / year	-	666	211	-	225	631	-	300
E31	Total greenhouse gas emissions	kg CO_2eq/(m^2.month); kg CO_2eq/(m^2.year)	3643	1002	3950	2982	6159	1139	3458	6075

Ref. ind.	Indicator	Unit	Home 9	Home 10	Home 11	Home 12*	Home 13	Home 14	Home 15	Home 16
-	Surface area	m²	100	151	112	100	120	86	78	92
E1	Final thermal energy consumption	kWh / m².year	-	128	160	281	118	251	179	272
E2	Final electrical energy consumption	kWh / m².year	-	-	69	36	33	174	172	41
E4	Final energy consumption	kWh / m².year	-	128	193	316	-	251	278	303
-	Energy source for heating	-	Elec.	Natural gas	Heating oil	Natural gas	Natural gas	Elect.	Elec. + wood	Heating oil
E6	Energy use for heating	kWh / m².year	-	107	123	241	102	174	146	262
-	Final energy source for DHW	-	Elect.	Natural gas	Elect.	Natural gas	Natural gas	Natural gas	Elec.	Elec.
E7	Energy use for DHW	kWh / m².year	-	21	37	40	16	76	33	10
E13	Total renewable thermal energy production	kWh / year	0	0	0	0	0	0	0	0
E14	Total renewable electrical energy production	kWh / year	0	0	0	0	1713	0	0	0
E15	Total renewable energy production	kWh / year	0	0	0	0	1713	0	0	0
E19	Primary thermal energy consumption	kWh / m².year	-	128	215	281	84	525	378	287
E20	Primary electrical energy consumption	kWh / m².year	-	-	179	92	84	449	445	106
E21	Primary energy consumption	kWh / m².year	255**	128	298	373	-	525	498	367
E28	Total greenhouse gas emissions (thermal)	Kg CO_2 eq / year	-	3971	4717	5750	2901	2200	683	7851
E29	Total electrical greenhouse gas emissions	Kg CO_2 eq / year	-	-	443	204	224	854	768	215
E31	Total greenhouse gas emissions	kg CO_2eq/(m^2.month); kg CO_2eq/(m^2.year)	-	3971	5160	5954	3125	3054	1451	8066

*: House that has been completely renovated
**: this value also considers electricity consumptions from others domestic uses.

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Table 14: Reference values used for baseline KPIs calculation

Parameter	Value	Reference
Conversion factor from final to primary electrical energy	2.58	National regulation
Conversion factor from final to primary energy for other energy sources	1	National regulation
Emission factor of the French electricity grid (kg CO_2 eq/ kWh)	0.0571	Base carbone - Ademe
Emission factor for French natural gas (kg CO_2 eq/ kWh)	0.205	Base carbone - Ademe
Emission factor of heating oil (kg CO_2 eq/ kWh)	0.324	Base carbone - Ademe
Emission factor of wood (kg CO_2 eq/ kWh)	0.0295	Base carbone - Ademe

These figures show that the energy performance levels of these houses before retrofitting are heterogeneous (see Figure 11). Some of the homes (5, 7, 12, 14 and 16) present higher values in thermal aspects, which reinforce the «heterogeneous» way to plan the retrofitting as stated before.

In terms of CO_2 emissions, Figure 12 shows that electric heating systems are responsible of quite low CO_2 emissions, even if they are not very efficient and consume a lot of energy (especially primary energy due to a conversion factor of 2.58) as, for instance, home 14. This is due to the French electricity production mix, in which nuclear energy plays a very important role.

On the other hand, gas or heating-oil systems, which are often very old, appear to emit a lot (see home 16 graph). In this sense, this data, even partial, nevertheless makes it possible to quickly identify the main work items to be carried out by the owners in order to reduce CO_2 emissions.

For houses with electric heating systems, it is essential to improve insulation. For houses with outdated gas or oil boilers, reducing CO_2 emissions requires insulation work, but also installation of more efficient heat production systems (heating and domestic hot water).

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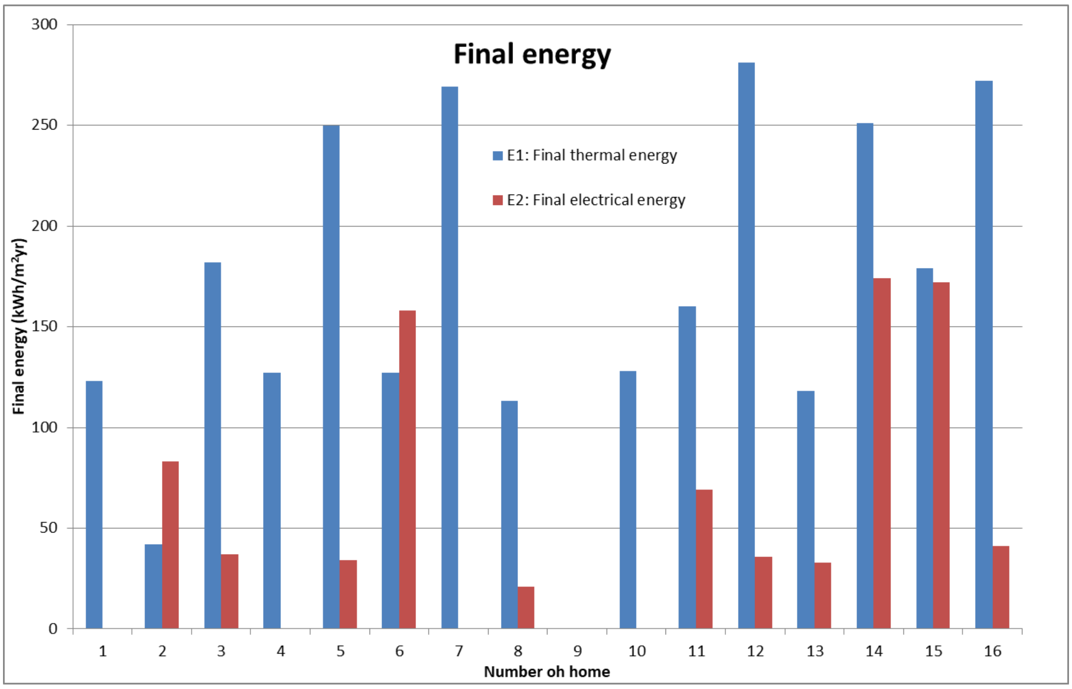

Figure 11: Final thermal and electrical energy of the 16 homes

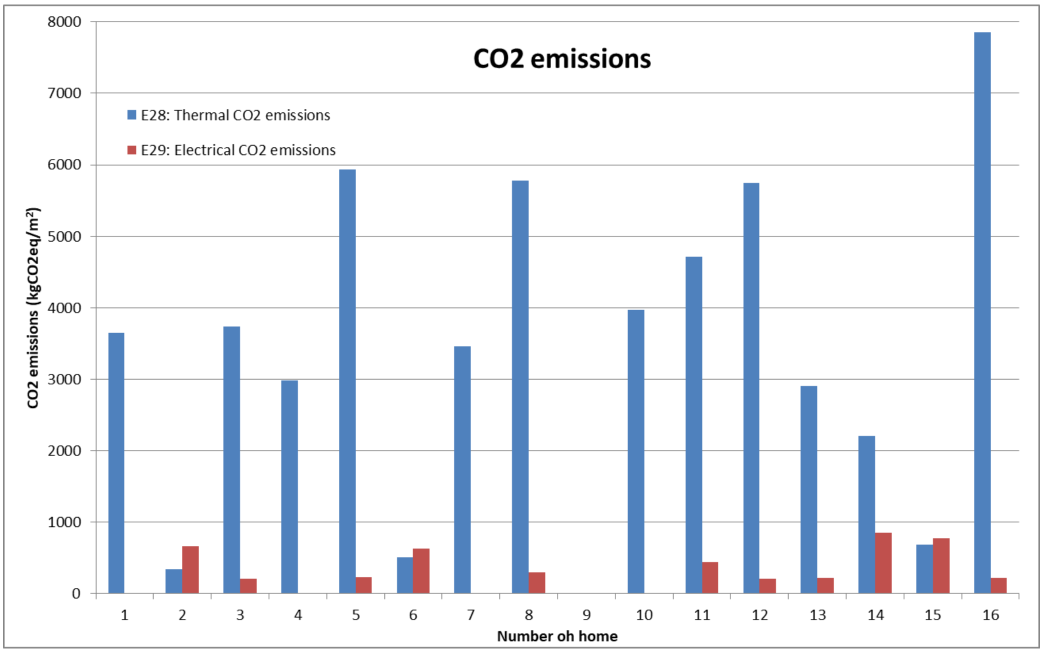

Figure 12: CO_2 emissions for thermal and electrical consumption

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4.5 New construction: Inspiration buildings (action 1)

4.5.1 Description of the action

On the western part of the Ile de Nantes, which is a new construction area, the Inspiration buildings construction, consists in the creation of a new set of high-performance buildings, comprising 4 blocks – 28,500 m² – 1,000 m² for shops, 1,250 m² for offices, 360 apartments, and a student home (145 dwellings). The building will be connected to the district heating for heating and domestic hot water demand. Innovations include installation of bicycle parking spaces in each residence, integration of housing in co-renting and mutability of dwellings upon request. Like some hotels, a concierge service common to all four blocks also offers a range of personal services (parcel delivery, key safekeeping, shopping reception... all on request). Finally, digital lockers have been set up to allow the deposit of personal belongings. The buildings were inaugurated on 11 July 2019. The action consists in monitoring the energy consumption of this high-performance building, including heating from district heating.

Figure 13: Pictures of the new Inspiration programme (credits: V. Joncheray / SAMOA)

4.5.2 KPIs, methodology and baseline values for evaluation

This action aims to build an exemplary building in terms of energy consumption, going beyond the performances set by national regulations. It also aims to take advantage of the proximity of the Centre-Loire district heating to connect this building to the heating network and thus take advantage of an efficient heat supply source largely supplied by renewable energies.

The selected KPIs to assess the aforementioned objectives and defined within “D5.1 Integrated evaluation procedure” are mentioned in the tables below, as well as baseline values reported in the BEST table. Note

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that the baseline values in new construction are the national regulation (minimum requirements to be covered). These values come from regulatory calculations related to new buildings constructions, using in particular normalized weather conditions related to the city of Nantes and normalized parameters (such as heating temperature). The table also includes the expected improvement according to the BEST tables, which will be assessed during the reporting period in D5.5.

Table 15: KPIs and baseline values of Inspiration building (28,500 m²)

Ref. indicator	Indicator	Unit	National requirements	Expected improvement
E1	Annual thermal (final) energy consumption	kWh / m².year	Heating: 48 kWh / m².year DHW: 22.8 kWh / m².year Total: 70.8 kWh / m².year	Heating: 38.5 kWh / m².year DHW: 16.7 kWh / m².year Total: 55.2 kWh / m².year
E4	Annual (final) energy consumption	kWh / m².year	74.7 kWh / m².year	58.3 kWh / m².year
E19	Annual thermal (primary) energy consumption	kWh / m².year		55,2 kWh / m².year (conversion factor from final to primary energy for DH = 1)
E21	Annual (primary) energy consumption	kWh / m².year		55.2 kWh / m².year (no other uses considered)
E26	Degree of heating supply by district heating	% of kWh/year	No requirement	100%
E28	Total greenhouse gas emissions (thermal)	Kg CO_2 eq		2.3 (emission factor of the DH = 0.042 kg CO_2 eq / kWh)
E31	Total greenhouse gas emissions	kg CO_2 eq/(m^2.month); kg CO_2eq/(m^2.year)		2.3

Evaluation will consist on comparison between baseline values and real monitored consumption data that will be normalized with meteorological data (Table 6).

4.6 Installation of digital boilers (action 7) in 3 buildings: Pierre Landais (action 4), Oiseau des Iles and Albert Londres (action 5)

4.6.1 Description of the actions

Today, new technologies based on digital products are becoming more and more numerous, and require the use of data centres. Data centres create an increasing heat source while operating, and need to be cooled to continue to run properly. On the other hand, hot water demand is constant in every residential building and in some tertiary buildings.

New equipment has been developed to merge these two issues: the digital boiler. With this new technology, domestic water is heated thanks to the heat released by computing servers. It is an innovative energy recovery system.

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As part of action 7 of mySMARTLife project, several digital boilers, provided by 2 different manufacturers, will be installed in 2 buildings (Pierre Landais, Oiseaux des Iles).

By way of information, digital boilers had also been installed in a third building prior to the mySMARTLife project (Albers Londres building). From a formal point of view, this building is not within the scope of the mySMARTLife project (it was therefore not the subject of BEST tables). Nevertheless, the feedback that it offers will allow refining the evaluation that will be made of the installation of digital boilers in the two other buildings.

- **Pierre Landais building**

Pierre Landais building is a new municipal public building under construction (action 4) which is scheduled to open in 2020. It will bring together on the same site a municipal social restaurant and public shower/baths (historically located in the Madelaine-Champs de Mars district). This new building will allow the reception of people in fragile situations (homeless people, precarious workers, isolated people) and give them access to catering, hygiene and health services. Beyond its interest in social terms, this building is intended to be exemplary in environmental terms. The building will be connected to the district heating (action 17) and one digital boiler will be installed. This digital boiler, of QB-1 type (designed by the French company Qarnot) aims at producing 19 MWh / year and at covering 50 to 70% of hot water needs.

Figure 14: Infographics of Pierre Landais building (credits: Ville de Nantes)

- **Oiseau des Iles**

As Albert Londres, Oiseau des Iles is also a social housing building owned by Nantes Métropole Habitat. The building is located in the Ile de Nantes. The construction of the building started in 2010 and ended in June 2014. 26 apartments and 4 small houses are spread on 2,800 m² and on the first floor 548 m² are available to shops or tertiary activities. In 2014, heating and hot water were produced through a district heating. This district heating is working with a biomass and wood boiler (and gas as a second heating system). Nantes Métropole Habitat decided to install a digital boiler in this building after the first successful experiment in Albert Londres building.

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The digital boiler started working in January 2019. It stopped for a few months when the company closed in March 2019 because of shareholders difficulties, but then started again in July 2019, when the new contract was signed.

Figure 15: Oiseau des Iles building

- **Albert Londres**

As previously mentioned, this building is not part of the mySMARTLife project. Albert Londres is the name of a social building built in 2010 and owned by Nantes Métropole Habitat (social housing landlord). It is located on the North of Nantes. The building has 40 apartments, spread on 3,008 m².

From 2010 to 2016, heating and hot water were produced by a gas-condensing boiler. In 2016, a digital boiler has been installed in the building with an expected production of 44 MWh per year to heat domestic water. That represents about 60% of the domestic hot water demand of the building. The complement is still produced by the gas-condensing boiler. The digital boiler installed is of Tebios type, from Stimergy company. That was the only digital boiler available at that time and one of the first designed by Stimergy.

Figure 16: Albert Londres building in Nantes

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4.6.2 KPIs, methodology and baseline values for evaluation

In these three buildings, assessment will focus:

- on measuring the energy consumption avoided by the installation of digital boilers. This avoided energy is the energy produced by the digital boilers and transferred to the building's DHW supply system. The method chosen falls under Option B of the IPMVP protocol.

  For Albert Londres and Oiseau des Iles buildings, CO_2 savings will be calculated by considering emissions that the initial systems for DHW would have produced to provide the amount of energy avoided thanks to digital boilers.

  For Pierre Landais (which is a new building), CO_2 savings will be calculated by considering emissions that district heating would have produced to provide the amount of energy avoided thanks to digital boilers. Parameters to take in consideration for evaluation are given in the Table 16.

- on measuring the actual energy performances of the buildings, compared to the target values entered in the BEST tables (these data come from regulatory calculations).

  It should be noted that the Pierre Landais building is a new building, whose expected performances go beyond the national regulations.

  For Oiseau des Iles building, boilers were installed in a pre-existing building, built to comply with the regulatory performance level.

Table 16: Parameters for evaluation

Building	Surface area	System for DHW before or if no digital boilers installation	Emission factor	Source
Pierre Landais	933 m²	District heating (Centre Loire)	0.042 kg CO_2 / kWh	http://reseaux-chaleur.cerema.fr/contenus-co2-des-reseaux-de-chaleur-et-de-froid-arrete-du-11-avril-2018
Oiseau des Iles	2,204 m	District heating (Centre Loire)	0.042 kg CO_2 / kWh	http://reseaux-chaleur.cerema.fr/contenus-co2-des-reseaux-de-chaleur-et-de-froid-arrete-du-11-avril-2018
Albert Londres	3,008 m²	Gas-condensing boiler	French gas mix 0.227 kg CO_2 eq / kWh	Base carbone – 2015-20

While the main interest of the assessment is to measure the energy consumption avoided thanks to digital boilers, a more complete list of indicators has been defined in order to monitor the building consumptions more precisely. The list of all the indicators is given in the table below.

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

Table 17: KPIs related to the 3 buildings

Ref. indicator	Indicator	Unit	Pierre Landais		Oiseau des Iles		Albert Londres	
			KPI selected	Baseline value	KPI selected	Baseline value	KPI selected	Baseline value
E1	Annual thermal (final) energy consumption	kWh / m².year	x	195.90	x	109.8	x	103.2
E2	Electrical energy consumption	kWh / m².year	x	35.60			x	0
E4	Annual (final) energy consumption	kWh / m².year	x	231.50	x	109.8	x	103.2
E6	Energy use for heating	kWh / m².year	x	108.30	x	68.8	x	57.6
E7	Energy use for domestic hot water	kWh / m².year	x	87.60	x	41.0	x	45.6
E13	Total renewable thermal energy production adapted in Total thermal energy recovery	kWh / m².year	x	0*	x	0	x	0
E15	Total renewable energy production adapted in Total energy recovery	kWh / m².year	x	0*	x	0	x	0
E17	Degree of energy self-supply by renewable energy adapted in Degree of energy self-supply by energy recovery	%	x	0 (11%**; 27%***)	x	0	x	0
E19	Annual thermal (primary) energy consumption	kWh / m².year	x	195.90	x	109.8	x	103.2
E20	Primary electrical energy consumption	kWh / m².year	x	91.85			x	0
E21	Annual (primary) energy consumption	kWh / m².year	x	287.75	x	0	x	98.6
E26	Degree of heating supply by district heating	% of kWh/year	x	0*	x	100		
E28	Total greenhouse gas emissions (thermal)	kg CO_2 eq	x	40,244.72	x	10,164	x	63,639
E29	Total greenhouse gas emission (electrical)	kg CO_2 eq	x	4,746.26				
E31	Total greenhouse gas emissions	kg CO_2eq/(m^2.month); kg CO_2eq/(m^2.year)	x	44,991.01	x	10,164	x	63,639

* according to BEST table, 0% of RES and DH contribution by national regulation, then, assumed natural gas based production
** expected improvement considering total final energy consumption
*** expected improvement considering energy consumption for DHW

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

The numbers provided in the table above are obtained under the assumtions of the BEST table specifications. In this sense, the starting point for the project (rounded in red in Figure 17) is an energy demand of 231.5 kWh/m^2·yr due to the constructive elements (i.e. insulation of façades, windows…), while the renewable contribution is assumed as 0. In this sense, the connection with the district heating and the digital boiler will imply the contribution of the renewables to be demonstrated along mySMARTLife. Under this assumption, it is also estimated that the energy demand is covered by natural gas fired boiler as generation system for this baseline scenario.

		New or existing building [5]	National regulation for new built [6]	National regulation for refurbished buildings or normal practice (6a)	suggestedspecification [7]	improvement
kWh/m2yr	Subtotal sum of energy demand	0	231.5	0	212.5	8%
kWh/m2yr	Subtotal sum of RES contribution	0	0	0	163.4055028	
kWh/m2yr	Total BuildingNetEnergy Use	0	231.5	0	49.09	79%

Figure 17: BEST table for Pierre Landais comparing national regulation and expected impact

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

5. Energy and city infrastructures actions

5.1 District heating

The development of district heating is a key component of Nantes Métropole's energy policy. By giving priority to the production of heat using renewable or recovered energy, Nantes Métropole is demonstrating its determination to combat greenhouse gas emissions.

At the start of the project, more than 30,000 housing units, representing around 12% of the city's housing stock, were connected to one of the 6 district heating in the city.

The centre of Nantes agglomeration, and in particular the Ile de Nantes (that constitutes the main site of demonstration within mySMARTLife project), is served by the Centre-Loire heating network. It serves 18,000 housing units, including 5,800 on the Ile de Nantes.

In 2018, this district heating produced around 254,400 MWh of heat. It is supplied by 4 production sites:

- A waste sorting and recovery plant (CTVD)
- the biomass heating unit "Malakoff"
- the gas heating unit "Malakoff"
- the gas heating unit "Californie"

The heat production of these 4 units (data provided by the operator Erena) is shown in the table below (year 2018, in MWh).

Figure 18: Heat production of the Centre-Loire district heating (in 2018, MWh, source: Erena)

Production site	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug	Sept.	Oct.	Nov.	Dec.	Total
CTVD	22,628	20,727	21,863	17,646	11,589	7,993	6,942	4,250	7,981	14,465	20,832	21,458	178,374
Heating unit biomass Malakoff	6,010	7,046	7,982	1,323	1,396	0	0	0	0	0	5,859	10,127	39,743
Heating unit gas Malakoff	3,845	10,744	3,804	1,631	558	49	0	611	111	1,980	3,052	1,463	27,848
Heating unit gas Californie	1,040	2,021	1,608	87	71	0	0	1,733	0	401	906	592	8,459
Total	33,523	40,538	35,257	20,687	13,614	8,042	6,942	6,594	8,092	16,486	30,649	33,640	254,424
% RES	85,4%	68,5%	84,6%	91,7%	95,4%	99,4%	100%	64,5%	98,6%	85,9%	87,1%	93,9%	85,7%

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

From a formal point of view, no physical intervention action on the Centre-Loire district heating is included in the mySMARTLife project. On the other hand, the mySMARTLife project concerns buildings that were already connected to the network: Oiseaux des Iles; or buildings to be connected by the project: Inspiration, Nantes-Paris, Pierre Landais..

Covering the heat needs of these buildings (heating and domestic hot water) will therefore benefit directly from the renewable energy sources that feed the Centre-Loire district heating. The proportion of renewable energy in the heating district heating varies from year to year. The public service delegation contract entrusted to Erena targets a value of 84% by 2021/2022.

5.2 Public lighting optimization (action 18)

5.2.1 Description of the action

As part of mySMARTLife project, a street lighting management system has been deployed in Nantes city centre, to reduce energy consumption using gradation, to optimize maintenance and to adapt public lighting to citizens' needs. The area chosen for this demonstrative action is a nice pedestrian zone along the Loire river, that is just next to the very busy "Quartier des Machines", where tourists, businessmen, inhabitants, students are mixing together at day and night in the Island of Nantes district.

Specifically, the action consisted in replacing or modernizing 80 light points equipped with LED technology and controller devices, in order to:

- adapt the lighting system to urban transformation of this area of the city: reduce the noise and pedestrian circulation in the new housing zone
- improve 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 (objective: 78% of energy and CO_2 emission savings compared to the previous situation).

Table 18: Description of interventions on public light points

Nature of interventions	Number of light points	Power (kW) BEFORE	Power installed (kW) AFTER
Remote management implementation on existing light points	35	1.4	1.4
Installation of new light points equipped with remote management	7	0	0.2
Substitution of existing light points with new ones equipped with remote management	37	5.8	1.7
Substitution of existing light points with new ones without remote management	1	0.2	0.03
Removal of existing light points	35	5.6	0
TOTAL		108 light points 12.9 kW	80 light points 3.24 kW

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

The implementation area of the new lighting management system has been divided in 5 zones (Figure 19), depending on the lighting needs. The system is based on communicating sensors deployment and supervision platform implementation that enables street lighting infrastructure monitoring and control, answering luminaire remote management, presence detection (in one specific zone) and citizens guiding.

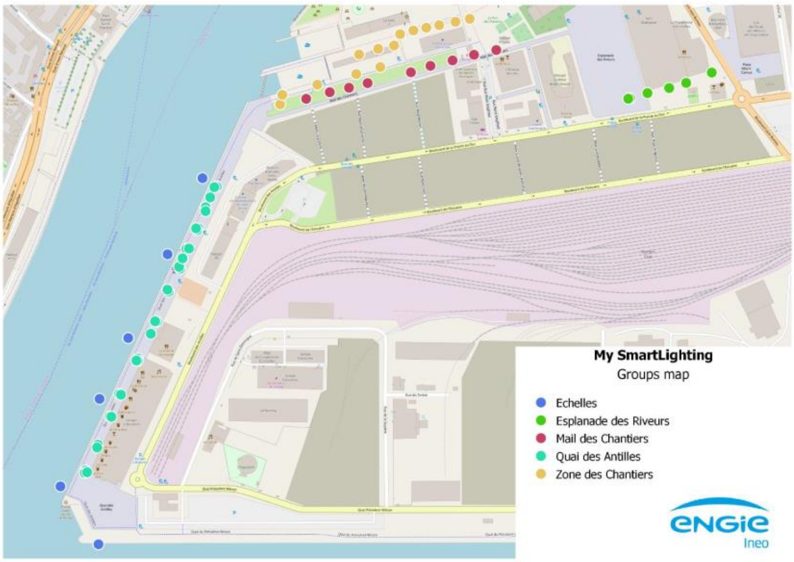

Figure 19: Map of the 5 zones of the new lighting system's implementation

Each zone corresponds to a programming scenario described in table below, and Figure 20 shows an example of dimming schedule programmed on the Mail des Chantiers zone.

Table 19: Programming scenarios

Area	Context	Needs	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 70% when 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.

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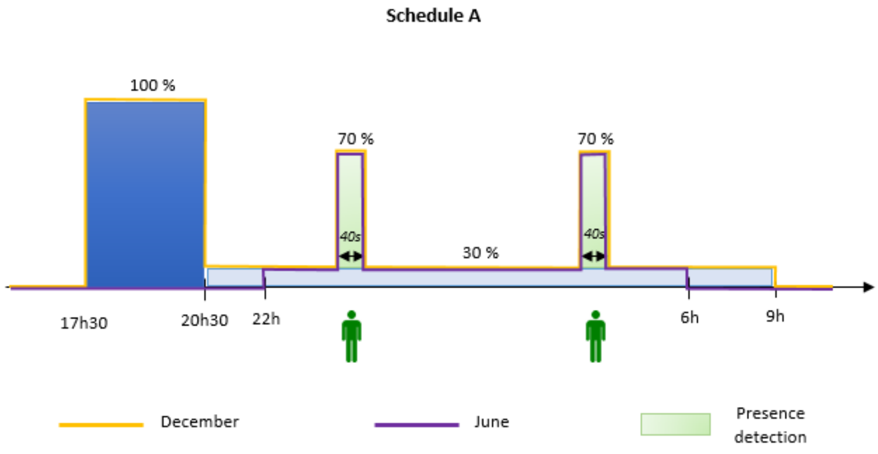

Figure 20: Typical dimming schedule

5.2.2 KPIs for evaluation

In relation with D5.1 Integrated evaluation procedure, the following KPIs have been defined to evaluate the action.

Table 20: KPIs related to action 16

Ref. indicator	Indicator	Unit
E2	Electrical energy consumption	kWh / month
E4	Annual energy consumption	kWh / year
E8	Energy use for lighting	kWh
E20	Primary electrical energy consumption	kWh / month
E21	Total primary energy consumption	kWh / year
E30	Total greenhouse gas emissions (lighting)	Kg $CO_{2\ eq}$ / month
E31	Total greenhouse gas emissions	Kg $CO_{2\ eq}$ / month
E32	Reduction of total greenhouse gas emissions	%

5.2.3 Baseline values and calculation methodology used

Baseline values of previous KPIs have been determined through simulations, realised according to the following methodology.

Lighting points ignition is driven by astronomical clock, adjusted on Nantes situation. It provides the lighting durations per month.

As the installation power of the previous lighting system was 12,945 kW, it is possible to estimate the energy consumption of the initial lighting points with the following formula:

Monthly energy consumption = Monthly lighting time (given by astronomical clock) x installation power

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In addition, the table below gives the reference values currently used in France in terms of emission factor of the national electricity grid and of conversion factor from final to primary electric energy.

Table 21: Reference values

Indicator	Unit	Value	Source
Emission factor of the French electricity grid	kg CO_2 eq / kWh	0.0571	Ademe, Base Carbone - 2018-20
Conversion factor final / primary electricity	-	2.58	National regulation

Finally, KPIs values related to the initial situation are given in the two tables below:

Table 22: Monthly KPIs related to the baseline situation

Month	Lighting time (in Nantes)	Energy consumption (kWh)	CO_2 emissions (kg CO_2 eq)
January	446 h	5,773	329
February	380 h	4,919	280
March	356 h	4,608	263
April	292 h	3,780	215
May	254 h	3,288	187
June	223 h	2,886	164
July	244 h	3,158	180
August	286 h	3,702	211
September	328 h	4,246	242
October	390 h	5,048	288
November	422 h	5,463	311
December	459 h	5,942	339
Annual	**4080 h**	**52,817**	**3,015**

Table 23: Baseline values of KPIs

Ref. indicator	Indicator	Unit	Baseline values from simulation
E2	Electrical energy consumption	kWh / month	See Table 22
E4	Annual energy consumption	kWh / year	52,817
E8	Energy use for lighting	kWh	52,817
E20	Primary electrical energy consumption	kWh / month	136,269
E21	Total primary energy consumption	kWh / year	136,269
E30	Total greenhouse gas emissions (lighting)	Kg $CO_{2\,eq}$ / month	
E31	Total greenhouse gas emissions	Kg $CO_{2\,eq}$ / month	3,015
E32	Reduction of total greenhouse gas emissions	%	To be calculated during evaluation phase

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All these values will be compared to the energy consumption values provided by the streetlight management system used by Engie, in order to provide KPIs related to the new lighting system and thus, to evaluate the results of the action.

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6. Mobility actions

6.1 Overview of the actions

Within the perimeter of Nantes Métropole, transport represents the main sector of greenhouse gas emissions (49% of total emissions). Nearly 88% of these emissions are generated by cars and 11% by public transport. Therefore, transport represents an essential lever for significantly reducing the city's emissions.

As part of the mySMARTLife project, and in application of its new urban mobility plan, Nantes Métropole is carrying out several actions in the field of mobility.

These actions are mainly aimed at the development of electric transport solutions, and concern both public transport vehicles (electric buses and their recharging device, autonomous shuttle: (**actions 23, 23b, 24**), and the development of recharging infrastructures for individual electric vehicles (**actions 25, 27, 31**).

There are also actions to test new urban logistics solutions (**actions 28, 30**) and to optimise the management of company vehicles fleets (**action 29**).

6.2 Deployment of 22 full-electric 24-meters buses and charging infrastructure (actions 23 and 24)

6.2.1 Description of the action

This action is one of the flagship actions of the Nantes demonstration site. It consists in deploying 22 full-electric buses on line 4 of the Nantes transport network.

Bus line 4 is a bus line with a high level of service (bus rapid transit), covering 7 kilometres, most of which are on dedicated right-of-way. This is the reason why the line is named “Busway”. Busway line 4 connects three municipalities in the South-eastern part of the Nantes agglomeration.

The Busway line 4 has been in operation in Nantes agglomeration since November 2006. It was one of the first lines of this type in France.

Today the fleet of buses running on the line is composed of twenty-three (23) Mercedes-Benz “O 530 Citaro G CNG” buses. These buses are 18-meters long articulated vehicles and can at top capacity host 110 passengers.

The "e-Busway" project consists on launching a new stage in the evolution of the line by acquiring 22 full electric vehicles (24-meters long) allowing the accommodation of approximately 150 passengers, which constitutes an increase of the transport potential of 35% at peak hours.

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

Nantes Métropole and SEMITAN (public transport operator) have chosen to deploy the Hess lighTram® 25 (Figure 21). The Swiss company Carrosserie HESS AG produces the chassis as well as the bodywork, and ABB company provides the propulsion system as well as the charging system, called TOSA.

Figure 21: Picture of one eBusway (Credit: Guillaume Costeseque)

The charging system chosen on the eBusway is a "bottle feeding" system. It charges the vehicle's batteries (electrical storage capacity of 128 kWh, located on the roof of the bus) during its stops. They are charged through stations which are connected to the general electricity network. At each equipped station, the vehicle is quickly recharged using a telescopic device mounted on the roof of the bus (Figure 22). This charging process takes place only during the dwell time, while the passengers get on and off.

In Nantes, charging points have been deployed at terminal stations (Foch and Vertou stations, 6 charging points), at 2 intermediary stations (Gréneraie and Beaulieu stations, 4 charging points) and in the new buses depot (Cetex, 2 charging points). At each point, the connection power is 600 kVA, offering an output power of approximatively 550 kW.

Figure 22: Close-up pictures of the recharging prototype system (Credit: Christiane Blanchard)

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

6.2.2 KPIs for evaluation and baseline values

In relation with D5.1 Integrated evaluation procedure, the following KPIs have been defined to evaluate these 2 actions (e-buses and charging system) and their impacts.

Table 24: KPIs and baseline values for actions 23 and 24

Ref. indicator	Indicator	Unit	Baseline values (refers to GNV buses)	Comments
M5	Annual distance travelled	km	2017: 959,490 km 2018: 981,063 km 2019: 890,791 km	Source: Semitan
M9	Annual energy consumption	kWh	2015: 9,074,000 kWh 2016: 8,918,500 kWh 2017: 9,216,000 kWh 2018: 9,425,000 kWh 2019: 8,900,000 kWh	Source: Semitan Fuel : Natural gas for vehicles
M10	Energy consumption per distance travelled	kWh / km	9,6 kWh / km	Average ratio
M3	Average number of passengers per working day	#	26,274 passengers / working day	Average ratio (based on values from Dec. 2017 to Sept. 2019)
M7	Availability rate of buses	%	95%	
M8	% of e-buses equipped with data collection	%	10%	
-	Annual CO_2 emissions	t CO_2eq / year	2,342 t CO_2 eq	
M13	Annual CO_2 emissions saved	t CO_2eq / year	No baseline	To be calculated during evaluation
M1	Annual number of passengers	#	9,809,000	Source: Semitan (2018)
M4	Annual number of trips	#	To be completed.	
M6	Average distance travelled by trip	Km / trip	To be completed	
M16	Annual energy delivered by each charging point	kWh / year	No baseline	Not in operation before implementation of the action
M19	Number of charges per charging point per year	#	No baseline	Not in operation before implementation of the action
M17	Annual energy delivered by all charging points	kWh / year	No baseline	Not in operation before implementation of the action
M18	Average energy delivered per charging operation and per charging point	kWh	No baseline	Not in operation before implementation of the action
M29	Station uptime per year	%	No baseline	Not in operation before implementation of the action
M31	Percentage of electricity supplied to charging stations by renewable energy sources compared to the total electricity supplied	%	No baseline	Not in operation before implementation of the action
M12	Average energy consumption per trip	kWh / trip	To be completed	

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6.2.3 Methodology and reference values to be used for calculation of CO_2 savings

Calculation of CO_2 emissions savings will be calculated by comparing:

- Emissions due to the electricity consumption of the new e-buses

CO2 eq emissions (t) = annual quantity of energy consumed by new e-buses (kWh) x emission factor of the French electricity grid (t CO2 eq / kWh)

and

- Emissions that former GNV buses would have emitted by travelling the same distances

CO_2 eq emissions (t) = annual distance travelled by new e-buses (km) x emission factor of former GNV buses (t CO_2 eq / km)

The table below gives the values to be used for Nantes situation.

Table 25: Reference values to be used for evaluation of actions 23 and 24

Parameters	Unit	Values	Source
Emission factor of the French electricity grid	kg CO_2 eq / kWh	0.093	CoM Default Emission factors for the Member States of the UE[8]
Average energy consumption per km of old buses	kWh / km	9.6	Baseline (Table 24)
Emission factor of GNV fuel	kg CO_2 eq / kWh	0.28	CoM Default Emission factors for the Member States of the UE (mobile sources, long cycle assessment value)
Emission factor of old buses	kg CO_2 eq / km	2.69	Calculation from Baseline

6.3 Experiment of autonomous shuttle and solar road (action 23b)

6.3.1 Description of the action

This action consists on an experiment of an autonomous electric shuttle and a solar road as an innovative solution to produce renewable electricity to charge the shuttle outside of its driving periods.

For Nantes Métropole, this project aims at testing a new means of public transportation with associated innovative equipment, having in mind to add it to its mobility offer for short-distance needs. The goal of the experiment was to get a precise idea of the abilities of this type of new vehicle and equipment.

A first experiment was done in June 2018 (out of the scope of mySMARTLife project), during a short event and on a path outside the general traffic flow. This second experiment aimed at testing the vehicle and the charging infrastructure over a longer period (March to May 2019) and on open roads.

[8] See: http://data.europa.eu/euodp/data/dataset/jrc-com-ef-comw-ef-2017

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

These experiments have been led by Nantes Métropole and Semitan (within the Nantes City Lab[9]), in collaboration with EDF (French electricity producer), Lacroix City, Charrier and ID4Car.

As for the first experiment, the vehicle chosen is the “Autonom Shuttle” by Navya.

Figure 23: Picture of the autonomous shuttle (Credit: Marie-Amélie Horvath)

For the second experiment, the deployment was realized on open roads in the activity park close to Nantes Atlantique airport, near Composite and Ocean Technocampus, the Jules Verne Technological Research Institute (IRT) and Airbus factory plant. The selected use case was to transport people from different companies in the airport activity area to an Inter-Company Restaurant (RIE for French “Restaurant Inter-Entreprises”), back and forth, during the meridian break i.e. between 11:30 am and 2:30 pm. The shuttle covered a 2.5 km long loop, serving three stations arranged for this occasion. Outside of its operating period, the shuttle was parked in a closed container.

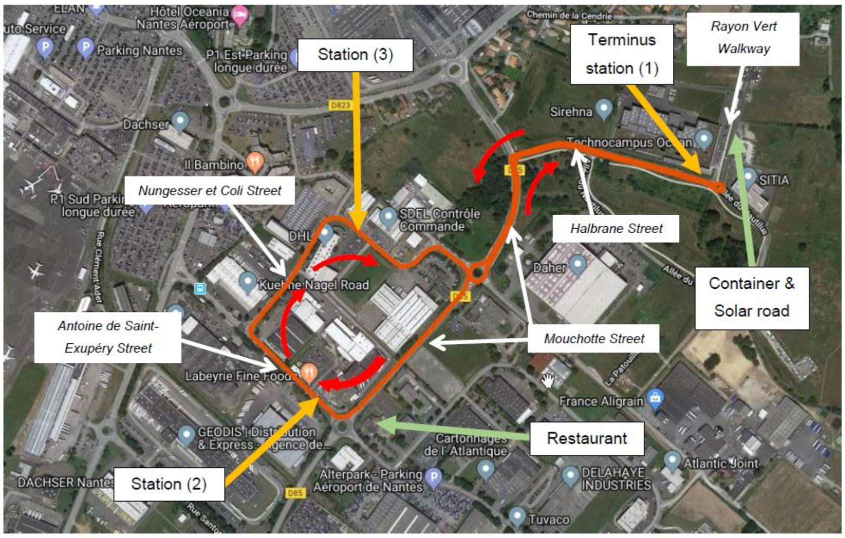

Figure 24: Shuttle itinerary

[9] The Nantes City Lab is the Nantes Métropole’s toll for supporting and implementing innovation on the territory.

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

About the solar road, a new prototype of the SOLIF® solution was developed by Charier for this second experiment. A 25-meters-squared surface of photovoltaic panels was installed on Rayon Vert Walkway. The panels consist in a thin surface of less than 1cm, including the glue. Each solar panel measures 115x81 cm, weighs 3 kg and has a maximal electric output performance of 150 Watt-peak in Standard Test Conditions. The electricity produced during the day was reinjected in the EDF electric network through an inverter and then, the autonomous shuttle was recharged during the night by connecting to the EDF network. There is no local storage with batteries.

6.3.2 KPIs for evaluation and baseline values

This action is a temporary experiment. Therefore, there are no baseline values.

Table 26: KPIs and baseline values for actions 23b

Ref. indicator	Indicator	Unit	Baseline values	Comments
M1	Total number of passengers during the experiment	#	-	Not in operation before implementation of the action
M3	Average number of passengers per working day	#	-	"
M4	Total number of trips	#	-	"
M5	Total distance travelled	km	-	"
M6	Average distance travelled by trip	km / trip	-	"
M7	Availability of the shuttle	%	-	"
M9	Total energy consumption of the shuttle	kWh	-	"
M10	Energy consumption per distance travelled	kWh / km	-	"
M12	Energy consumption per trip	kWh / trip	-	"
M13	CO_2 emissions saved	T CO_2 eq	-	"
M14	Number of incidents and traffic accidents where the shuttle was involved	#	-	"
M35	Electricity produced by the solar road	kWh	-	"
M33	Rate of coverage of the shuttle's electrical needs by the solar road	%	-	"
M34	Availability of the solar road	%	-	"

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

6.4 Implementation of smart charging stations for individual e-cars (actions 25, 27 and 31)

6.4.1 Description of the actions

As part of mySMARTLife project, the deployment of recharging stations for electric vehicles refers to the implementation of 3 actions.

Action 25: Nantes Métropole is committed to the deployment, by 2020, of 65 smart and connected charging points for individual electric vehicles (EV) in the car parks located in the metropolitan area centre.

More specifically, Nantes Métropole commitment provides for the installation of “supervisable” charging points, divided into:

- 49 “slow” charging points
- 14 “accelerated” charging points
- 2 “fast” charging points.

Nantes Métropole’s commitment also covers deployment of 500 secure charging points for electric-assisted bicycles (e-bikes).

One of the components of the project is also to connect the vehicle charging points with the urban data platform, so that data related to use and functioning of the equipment can be tracked in the Nantes Métropole information system.

In a medium-term perspective, Nantes Métropole also aims at developing a new digital service in the “Nantes in my pocket” application, allowing users to be informed in real time about charging point availability.

Actions 27 and 31: these actions are aimed at deploying a neutral multimodal hub within the CIC bank building. These actions include the installation of one charging station for electric vehicles powered by solar panels (installed on the roof of the building) and an electricity storage system (batteries).

The whole system will optimize on-grid consumption of the building. The building, as well as the charging station for electric vehicles, will consume the stored renewable electricity during consumption peaks, maximizing the use of RES.

6.4.2 KPIs for evaluation and baseline values

In relation with D5.1 Integrated evaluation procedure, the following KPIs have been defined to evaluate this action and its impacts.

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

Table 27: KPIs and baseline values for actions 25, 27 and 31

Ref. indicator	Indicator	Unit	Action 25	Actions 27 and 31	Baseline values
M13	Annual CO_2 eq emissions saved	T CO_2 eq / year	x	x	No baseline. Not in operation before implementation of the action
M16	Annual energy delivered by each charging point	kWh / year	x	x	No baseline. Not in operation before implementation of the action
M17	Annual energy delivered by all charging points	kWh / year	x	x	No baseline. Not in operation before implementation of the action
M18	Average energy delivered per charging operation and per charging point	kWh	x	x	No baseline. Not in operation before implementation of the action
M19	Number of charges per charging point per year	#	x	x	No baseline. Not in operation before implementation of the action
M20	Total operating time of charging operations	hours / year	x	x	No baseline. Not in operation before implementation of the action
M21	Average duration of charging operations	hours	x	x	No baseline. Not in operation before implementation of the action
M24	Number of different users per year	#	x	x	No baseline. Not in operation before implementation of the action
M29	Station uptime per year	%	x	x	No baseline. Not in operation before implementation of the action
M30	Charging point powered with renewable energy (number and rate)	# and %	x	x	No baseline. Not in operation before implementation of the action
M31	Percentage of electricity supplied by renewable sources	%		x	No baseline. Not in operation before implementation of the action

6.4.3 Methodology and reference values to be used for calculation of CO_2 savings

One of the most important aspects of the evaluation of these actions is the estimation of avoided CO_2 emissions.

The charging stations deployed are intended for the general public, for charging individual private vehicles. They will be connected and will collect a large amount of data on charging sessions, but they will not allow knowing the actual use of the electric vehicles.

In particular, data concerning the distances travelled using the electricity delivered by the stations will not be accessible. Similarly, it will not be possible to know the precise impact of each of the charging stations on the development of the fleet of electric vehicles. In other words, it will not be possible to know whether

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the electric vehicles coming to be recharged at the charging points actually replace journeys previously made by internal combustion engine vehicles.

In view of these uncertainties, CO_2 savings will be estimated taking into account the following assumptions (see D5.1):

- The principle of the evaluation is to compare:
    1) the emissions associated with the journeys made in electric vehicles thanks to the electricity delivered by the stations

    with

    2) the emissions that would have been produced by internal combustion vehicles if they had run the same journeys. Therefore, it is implicitly considered that electric vehicles replace internal combustion vehicles under similar conditions of use (journeys of the same distance).
- The emission rates (emissions / km) of the internal combustion vehicles that electric vehicles replace correspond to the average emission rate of vehicles in the French fleet. This emission rate has been estimated by considering the emission rate of new vehicles put into service in the year corresponding to the average age of the French vehicle fleet.
- Emissions associated with the electricity charged by-e-vehicles are estimated by taking into account the emission factor of the French electricity grid.
- Distances travelled by e-vehicles are estimated taking into account the average energy efficiency of electric vehicles in Europe (0,18 kWh / km).

CO_2 eq emissions saved = CO_2 eq emission from ICE vehicles –CO_2 eq emissions from new e-vehicles

Considering:

- CO_2 eq emissions from new e-vehicles = annual quantity of energy charged (kWh) x emission factor of the French electricity grid (CO_2 eq / kWh)
- Distances travelled by e-vehicles (km) = annual quantity of energy charged (kWh) / average energy consumption (kWh / km)
- Distances travelled by ICE vehicles = Distances travelled by electric vehicles
- Emission rate of ICE vehicles = average value of the French car stock.

All the reference values to be used are given in the table below:

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Table 28: Reference values to be used for evaluation of actions 25

Parameters	Unit	Values	Source
Emission factor of the French electricity grid	kg CO_2 eq / kWh	0.093	CoM Default Emission factors for the Member States of the UE https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/COM-EF/dataset/comw/JRC-CoM-EF-CoMW-EF-2017.pdf
Average energy consumption of electric vehicles	kWh / km	0.18	
Average age of French cars fleet	year	9.3	European Automobile Manufacturers Association https://www.acea.be/publications/article/acea-pocket-guide
Average emission rate of French cars	g CO_2 eq / km	128	Eurostat https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=fr&pcode=sdg_13_10&plugin=1

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7. Conclusions

By way of conclusion, it is possible to retain the main points highlighted by the baseline in this deliverable, as well as the complexity of performing a fine-tuned baseline. In this sense, it should be firstly remarked that Nantes Métropole is the 6th largest city in France by its population, with a dynamic metropolis, both in demographic and economic terms.

Having said that, it should be noted that this deliverable is a complement of the already submitted and approved city audit (D2.1) where city level indicators where used to establish the context of the city as a whole. In this second part, the baseline has been the main focus, which aims to set a reference status of the interventions (and actions) before the implementation of mySMARTLife. This deals with a group of multiple casuistries within the analysis:

- New buildings, which do not offer data about the performance and simulation tools are required to analysis the «designed» performance in order to compare with the as-built data during the operational stage.
- Existing building without data collection procedures that require the extraction of data from invoices and/or simulation strategies.
- Existing building with data collection approaches that allow to represent the current performance based on the gathered data.
- City infrastructures aiming the increase of renewables penetration.
- Mobility actions that are needed to be comparable with similar strategies in the past (e.g. substitution of fuelled vehicles by electrical ones).

To overcome the baseline assessment in Nantes, IPMVP has been selected as the protocol for the measurement and verification, which is a well-known methodology to evaluate energy savings. This protocol, complemented with the indicators defined into D5.1, has been proved as a valid framework under which the impacts of the mySMARTLife project can be verified within T5.5.

It must be highlighted that the detailed KPIs and the parameters that have been identified provide the framework under which adjustments can be done to compare the currents status with the improved one.

Finally yet importantly, with this basis, Nantes team considers that expected impacts as well as BEST tables will be validated, following a comparable procedure with other cities (Hamburg and Helsinki in the case of mySMARTLife).

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