BUILDING SMART CITIES TOGETHER

SHARING CITIES

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Konstantinos Zavitas

Carolina Carli
Francesco Causone
Sonia Cuhna
Stefano De Antonellis
Michele De Nigris
Pierpaolo Girardi
John Polak
Catarina Rolim
Eduardo Silva
Aruna Sivakumar
Anita Tatti
Andrea Temporelli

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1 INTRODUCTION

1.1 The SHARING CITIES project

The Sharing Cities (ShC) lighthouse program is a proving ground for a better, common approach to making smart cities a reality. The program ambitions to achieve a wide scale deployment of smart cities solutions, shift the thinking to decarbonized and local renewables and to make the active engagement of citizens a reality. Furthermore, the program aims to demonstrate and assess how the innovative use of technologies can improve city life and the lives of its inhabitants by promoting improvements in urban mobility, energy efficiency in buildings and carbon emissions while engaging citizens and fostering local level innovation, creation of new businesses and jobs.

Integrating physical, digital and human systems in urban setting, ShC will test and deliver sustainable forms of place management through the implementation of several measures categorised in three distinct but interconnected core subjects: People, Place and Platform. People concerns the development of new people-centred services and tools enabling the understanding of society by engaging citizens to actively participate in the transformation and improvement of their living contexts. The main goal of Place is to demonstrate real tangible value of integrated urban infrastructures and services through the deployment of new shared, digital-first, scaled and market accelerator initiatives that will lead to low energy districts and sustainable mobility: Building Retrofit; Sustainable Energy Management System; Shared eMobility; and Smart Lampposts. Connecting People and Place, and urban sharing Platform will combine technical components, capabilities and processes of the interventions, managing the data collected from a wide range of sources (e.g. devices and sensors) which will provide the functions and services that enable a Smart City by presenting information to the city and citizens.

1.2 Monitoring & Evaluation

The main objective of work package 8 (WP8) is to deliver an assessment of the effects of the People, Place and Platform (PPP) initiatives, monitoring and evaluating the impacts of the measures deployed and specific local demonstrators within the ShC project. This monitoring and evaluation will enable the impacts of the project to become relevant to the wider policy and innovation community.

This monitoring and evaluation work consists of two elements:

1. Methods to enable the impacts of the specific PPP measures implemented in the partner cities to be reliably understood, quantified and evaluated.
2. A Toolbox of models and methods to enable these results to be used as a basis for the development of future policy, technology and business models. In particular enabling both the scaling up of existing PPP measures and the translation, replication and evolution of these measures to cities across Europe.

The monitoring and evaluation is based on a clear and explicit set of principles that guide the development of evaluation methods. Such a principles-based approach assists in avoiding the risks associated with an ad hoc and fragmented case-based approach. There are six key principles that guide the work presented in this deliverable. These include the development of a **common framework**, that defines the evaluation targets to be addressed and the evaluation methods used and of **local implementation strategy**, that takes into account the detailed local knowledge only available at the local partners' levels to implement the framework. Another key principle is **target salience**, related with the selection of evaluation targets based on their salience in respect of its policy and market significance, its practical contribution to scaling and replication together with the practical

opportunities for the collection of relevant high-quality monitoring data. The 4th key principle concerns the **control for covariates**, meaning that for each measure it will be crucial to take into account the different factors that can influence a particular outcome or evaluation target due to the complex environments in which the several measures will be deployed. The development of a **Common core** of evaluation and associated KPIs, data and measurement processes implemented in a consistent manner across all three cities is another key element of the monitoring and evaluation work package, since it will provide the fundamental mechanism by which the ShC project will be able to aggregate experience and learning across the participating cities and indeed more widely. The final key principal is the definition of a **Dimension of impacts**, since the measures implemented in the project will have a wide range of different types of impacts on different stakeholders and that these impacts may change over time as stakeholders learn and adapt their behaviour and as the measures themselves are evolved. As such, the monitoring and evaluation work package proposes these impacts to be organized under five broad headings: technical performance, institutional and business consequences, impacts on attitudes and behaviours, wider systemic impacts (environmental, security, safety and sustainability) and, economic and social implications including those affected by efficiency equity and social inclusion.

1.3 Site-specific Monitoring Programs

A number of different core and city-specific data collection protocols will have to operate in each city. It is vital that these different protocols operate smoothly and that they be managed as a coherent programme of work, with clear responsibilities and solid processes of quality control. The objective of this task is design a coherent monitoring programme for each city and to define the way in which this programme should be managed to achieve and maintain high quality data over an extended period of time.

The task will establish in each city a local evaluation programme delivery team and define a number of quality metrics which will form the basis of the effective management of the monitoring programme over time. For example, if panel surveys are used, criteria will be established for refreshing the panel to avoid problems of panel conditioning. Similarly, the quality of the data generated by the various protocols will be continuously monitored and corrective action taken if problems are detected.
The monitoring programme will also be responsible for augmenting the data collected directly by the project with relevant local contextual information (covariates) that will enable the influence of local conditions to be properly taken into account in the subsequent analysis. The data generated by the monitoring programme will be archived in the platform together with appropriate meta data and quality descriptors.

1.4 This Deliverable

The local monitoring programs (LMPs) are developed in collaboration with local authorities and demonstrator operators. Agreement among all stakeholders from early on in the monitoring process ensures continuous and complete data sets and is essential for the successful completion of the monitoring programme. The LMPs included in this report are outcomes of such consultations.

The DCPs described in D8.2, include several methods of data collection including surveys and behaviour sensing. The LMPs presented in this deliverable are not considered binding and are revisited, as the evaluation and monitoring partners see fit to improve the quality of data collection.

In this deliverable for each demonstrator type, a detailed description of the stakeholders involved in the monitoring process is provided. Their responsibilities are described in terms of:

- design of monitoring/ data collection specifications,

- undertaking the procurement,
- installing the equipment,
- collecting/ communicating data
- storing the data,
- undertaking analysis, and
- dealing with privacy issues.

A chronological description of the data collection program is provided, to better capture each stakeholders' responsibilities within the program. For each demonstrator project type, a detailed Table is provided, describing the various types of responsibilities for each measurable indicator and evaluation target separately. In case two or more partners are responsible for a specific action, an additional explanatory note is always included to clarify the responsibilities and nature of involvement of each.

The Deliverable is structured as per the monitoring programme structure of each lighthouse city. Chapter 2, Chapter 3, Chapter 4 and Chapter 5 describe the Lisbon monitoring programmes for buildings retrofit, SEMS, mobility and lampposts respectively. Chapter 6 and Chapter 7 describe Greenwich retrofit and SEMS demonstrators, and mobility and lamppost demonstrators respectively. Chapter 8 and Chapter 9 describe Milan retrofit, SEMS and mobility demonstrators respectively. Finally, the monitoring programmes for city context data requirements, information on the data platform approach adopted in each city and the Digital Social Market implementation at each city are described in Chapter 10.

2 LISBON BUILDING RETOFIT AND LOCAL RENEWABLE ENERGY GENERATION

In Lisbon the retrofit actions are performed in three different building types: public residential buildings, private residential buildings and social housing buildings. Taking this into account, the retrofit actions were selected for each building type considering their different needs and restrictions. The main actions aimed for a reduction of primary energy consumption, increase of comfort levels for the occupants and increase of renewable use. The improvement of the buildings performance is achieved through enhancements on the buildings envelope (e.g. façade insulation, roof insulation, windows replacement and glazing replacement) and technical systems, with the improvement of lightning systems (installation of efficient LED light bulbs), replacement of HVAC systems and installation of heat pumps. The installation of PV panels will contribute to increase the use of renewable energy sources.

In order to assess and evaluate the impacts of these retrofit actions not only on the building performance but also in factors such as occupants' behaviours, business models, among others, a monitoring plan has been outlined for each of the buildings type. While these monitoring plans have been defined taking into account the several implementation stages and specifications of each building retrofit measures, data privacy issues and access to data through the Urban Sharing Platform still need to be confirmed. The monitoring plans will be presented in the following sections.

2.1 Private Residential Buildings

The private residential buildings retrofit in Lisbon is being undertaken by the private company Reabilita, whose business model is to purchase buildings in significant need of rehabilitation (completely vacant or practically vacant) rehabilitate them and sell the apartments to private consumers. Within the Sharing Cities program, 3 buildings within the pilot area of the project were selected for retrofit. In each of these buildings specific retrofit actions will be deployed aiming for a considerable improvement on the buildings energy efficiency. Table 2.1 summarizes the type of retrofit interventions considered for the three private residential buildings and its description.

Table 2.1: Summary of the type of retrofit interventions for the Lisbon private residential buildings

Type of building	Address	Area	Type of intervention	Description of intervention
Private residential	Rua Esperança do Cardal 11	424 m2	Insulation	Roof exterior 8 cm XPS
			Windows	PVC , low-e, 4-16 argon-4)
			Lighting	Replace lamps for LEDs
			DHW	Heat Pump (COP=2.7)
			Renewable Energy	13 PV pannels
	Rua de São Bento 614	933 m2	Insulation	Roof exterior 8 cm XPS
			Windows	PVC , low-e, 4-16 argon-4)
			Lighting	Replace lamps for LEDs
			HVAC system	Heat Pump (COP=3)
			DHW	Electric water heater AQS eff = 1
			Renewable Energy	10 PV pannels
	Avenida Almirante Reis 246	1 929 m2	Insulation	Roof exterior 8 cm XPS
			Windows	PVC , low-e, 4-16 argon-4)
			Lighting	Replace lamps for LEDs
			HVAC system	Heat Pump (COP=4)
			DHW	Heat Pump (COP=2.7)
			Renewable Energy	14 PV pannels

The impact of these measures will be assessed through a monitoring plan designed specifically for private residential buildings.

2.1.1 Implementation stages & timeline

The assessment of the measures applied in the context of private residential buildings is dependent on the selling and occupancy of the apartments, which cannot be guaranteed to happen within the project duration. Additionally, since the buildings selected were mostly unoccupied, no baseline data will be possible to obtain as well as no comparison analysis of before and after retrofit in terms of energy consumption. Furthermore, while the deployment of such measures is of the utmost importance to move cities towards their target of becoming smarter and more sustainable, three buildings are not representative of a city as a whole. As such, the monitoring plan was devised taking into account several aspects, not depending only on energy data and construction timings:

- Qualitative assessment of retrofit measures
- Overview of retrofit in energy consumption and renewable energy production
- Assessment of energy consumption and renewable energy production patterns
- Business model assessment
- Scale-up of building retrofit at a city-scale

Taking this into consideration, several implementation stages have been identified within the monitoring plan of the private residential buildings (see Table 2.2):

Stage 0: Qualitative assessment of retrofit done in Esperança do Cardal building
This stage is focused on the one building in which retrofit intervention are finished and with tenants already living in the apartments.

- Qualitative assessment of retrofit intervention (data from one tenant that lived in the building before and after the intervention): acceptance, satisfaction, comfort perceptions, impacts on behaviour change, etc.
- Impacts of retrofit in energy consumption and analysis of renewable energy production (data from one tenant that lived in the building before and after the intervention)
- Assessment of energy consumption and renewable energy production patterns from apartments and building common areas (data collection from new tenants is dependent on their authorization for data access)

Stage 1: Profiles
Given that two more buildings are still in construction with apartment sales occurring in the following months, this monitoring stage regards the impact of energy efficiency retrofit measure in the business model of Reabilita. For this two approaches will be considered:

- Energy efficiency retrofit pamphlet (in Annex A): to be presented to potential buyers when buying the apartment. This pamphlet will present the interventions done in the building and their advantages regarding energy consumption, pollutants emissions, savings and renewable energy production
- Household profiles: simulation of energy consumption and renewable energy production will be performed considering different household types and characteristics. These simulations will be presented to potential buyers of the apartments, demonstrating their energy consumption patterns and renewable energy production and, consequently, potential savings.

Stage 2: Retrofit policy
In this stage of the monitoring plan a wider assessment of this measure will be performed. Considering that this type of intervention in buildings that are old and/or unoccupied is not performed in all

buildings, an analysis on the impacts of a widespread adoption of energy efficiency retrofit in the city of Lisbon will be performed. For this, a benchmark analysis of the retrofit status, development, innovative solutions in the city of Lisbon will be undertaken, focusing on an assessment of existing retrofit measures (e.g. most popular measures, measures with most impact on energy efficiency, among others). Furthermore, this analysis will not only focus on the energy consumption and renewable energy production, but mainly on its potential influence on the development of future sustainable urban policies and regulations. As such, for the benchmark analysis, three groups will be considered:

- Retrofit status
- Wide-scale deployment of retrofit measures
- Urban policies and regulation

2.1.2 Data source specifications and timeline

Data will be collected through a set of data sources that will allow the analysis of the monitoring stages previously described. These data sources and the description of the type of data they will collect is presented in Table 2.2. The Lisbon private residential data will be collected through the following data sources:

- Energy meter: installed at building and apartment level enable monitoring energy consumption. Data on energy consumption at an apartment level will require tenants' authorization due to privacy issues. Energy meters will also collect data regarding renewable energy production and exportation.
- Interview to tenants: conducted to the tenant that lived at the Esperança do Cardal building, the first building in which retrofitted intervention is completed. This will allow to perform a qualitative analysis on the impact of the retrofit in the energy consumption patterns and behaviour change, as well as assess the tenant's satisfaction and comfort perception towards the intervention performed.
- Interviews to stakeholders: these will allow assessing stakeholders willingness to replicate and/or scale-up such an approach to similar buildings in the city of Lisbon, the impacts on business model, financial success, among others
- Interviews to decision-makers/policy-makers: assessing their willingness to define new policies promoting energy efficient retrofit in the city of Lisbon
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project
- External data: concerns data that will be collected throughout the monitoring period enabling the benchmark analysis on the impacts of retrofit practices in the city of Lisbon
- Simulated data: household profiles will be developed with simulated data on energy consumption and renewable energy production

Table 2.2: Private residential building monitoring data timeline (timeline is dependent on privacy issues)

Stage	Data Group	Data description	2018											2019											2020										
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			...	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 - Qualitative assessment	Z	Baseline + qualitative data (privacy data)																																	
Stage 1 - Profiles	A	Energy Efficiency Pamphlet																																	
	B	Household profiles																																	
Satge 2 – Retrofit Policy	D	Retrofit status																																	
	E	Wide-scale deployment of retrofit measures																																	
	F	Urban policies and regulation																																	

Table 2.3: Private residential data sources timeline

Data Source	Data description	Month																																
			2018				2019														2020														
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Energy meter	Renewable energy produced on the building site																																	
	Renewable energy produced and exported from the building site																																	
	Renewable energy produced and used on site																																	
	Grid electricity consumption (aggregated level)																																	
	Grid electricity consumption (apartment level)																																	
Interview to tenants	Qualitative data																																	
Interview to stakeholders	Business model impacts, replication																																	
Interview to decision/policy-makers	Policy-making and regulation																																	
Calculated data	CO2 footprint																																	
Monitored data	Benchmarket analysis																																	
Simulated data	Household profiles																																	

2.1.3 Partners and responsibilities

Table 2.4 summarizes the partners involved in the private residential buildings retrofit activities within the Sharing Cities program and the corresponding responsibilities of each partner. The table also presents data risks that can rise within the measure, in this case, related with privacy issues that can lead to the unavailability of data to analyse the impacts. Consequently, evaluation and monitoring activities might be delayed or adjusted. Furthermore, it is also possible to observe where the data collected will be accessible. In the case of Private residential buildings data will be sent by the responsible partners to the Urban Sharing Platform (USP), also developed within the program.

Reabilita is a Lisbon real-estate developer company focused on retrofitting old buildings. As such, Reabilita is responsible for implementing the retrofit measures selected to be deployed in the three Lisbon private buildings. They are also responsible for the procurement process and for selecting the contractor who will install the equipment. Reabilita will also facilitate the access to the new owners of the apartments in order to obtain authorization for data sharing and availability to participate in potential interviews and or surveys.

EDP-Distribuição (EDP-D) is the Mainland Portuguese distribution company, operating under regulatory supervision. Within the private building retrofit measure, EDP-D is the partner that will install the energy meters that will collect data on energy consumption profiles. Additionally, EDP-D will also provide access to the data: building aggregated data (in case privacy issues rise) and apartment data (if owners give authorization for data sharing).

Instituto Superior Técnico (IST) is the engineering school of Universidade de Lisboa, Portugal. IST is responsible for the analysis of available data that will allow assessing the impacts of the measures. IST will also be responsible for the conduct of potential interview and surveys to owners of the apartments and to stakeholders involved in the measure.

Lisboa E-Nova (LBN) is the Lisbon Municipal Energy and Environmental Agency. LBN work aims to contribute to sustainable development of the city by improving the overall energy and environmental performance of the city. Within the scope of private residential buildings retrofit LBN will supervise the progress of the activities and will contribute to the analysis of the available data.

Table 2.4: Private residential building partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
Energy meters	EDP-D/Reabilita	EDP-D/Reabilita	EDP-D/Reabilita	EDP-D	EDP-D		EDP-D/DGEG	Privacy (apartment level)	Yes
Interview to tenants	IST/LBN	-	-	IST/LBN	IST/LBN	.	IST/LBN	-	No
Interview to stakeholder	IST/LBN	-	-	IST/LBN	IST/LBN	.	IST/LBN	-	No
Interview to decision-maker/policymakers	IST/LBN	-	-	IST/LBN	IST/LBN	.	IST/LBN	-	No
Calculated data	IST/LBN	-	-	IST/LBN	-	.	IST/LBN	-	No
Monitored data	IST/LBN	-	-	IST/LBN	-	.	IST/LBN	-	No
Simulated data	IST	-	-	IST	-	.	-	-	No

2.2 Public Residential Buildings

Within the Sharing Cities program, the Lisbon Municipality has selected a social housing unit to retrofit. The unit, covering a build area of 20609 m^2, is composed by two housing blocks with a total of 10 buildings, comprising 248 dwellings inhabited approximately by 437 persons. While the retrofit interventions will be deployment covering all the area of the building units, however, for the purpose of the Sharing Cities program only an area covering 17212 m^2 was considered. The main retrofit actions implemented in the unit focus on increasing and improving the energy efficiency of the buildings as well as thermal comfort of the occupants. Additionally, PV panels will be installed in the roofs of the buildings increasing the buildings potential for renewable energy production. Table 2.5 presents the retrofit interventions for the Lisbon public housing buildings.

Table 2.5: Summary of the type of retrofit interventions for the Lisbon public housing buildings

Type of building	Address	Area	Type of intervention	Description of intervention
Public housing	Quinta do Cabrinha	17 212 m2	Insulation	Roof and façade exterior insulation with cork agglomerate 6cm
			Windows	PVC frame with double glazing (4mm + 16mm air + 4mm)
			Lighting	Replace lamps for LED in common areas
			Renewable Energy	869 PV pannels

A monitoring plan was developed in order to assess the impacts of the retrofit intervention in the buildings energy performance and, as such, on energy consumption and comfort level of its inhabitants. This monitoring plan requires the engagement of the inhabitants in its several stages entailing their authorization and access to private data and availability to assess their attitudes and perceptions regarding energy consumption, comfort levels and satisfaction with the interventions performed.

2.2.1 Implementation stages & timeline

The monitoring plan regarding the Lisbon public housing consists of several implementation stages defined not only accordingly with the retrofit intervention actions taking place but also considering the engagement of the inhabitants in the transformation of their living context, by educating and promoting the adoption of energy efficiency behaviours at home. The monitoring plan, as of now, consists of 5 stages that involve the collection and analysis of data (e.g. energy consumption, surveys, interviews, etc.) taking into account two specific groups: control and experimental group. An experimental group will be composed by a group of participants that will receive education on energy efficiency and feedback on their energy consumption performance. On the contrary, the control group will receive no information on energy efficiency and energy consumption patterns. This distinction will allow to assess the impacts of both energy efficiency education and retrofit interventions in people's energy consumption and comfort.

The five stages identified are:
Stage 0: Baseline

- Collection of historic data on energy consumption previous to the start of retrofit intervention

Stage 1: Energy Efficiency Session

- Group A: control group – no session on energy efficiency
- Group B: experimental group – session on energy efficiency

Stage 2: Feedback session

- Group A: control group – no feedback session on energy consumption
- Group B: experimental group – feedback session on energy consumption

Stage 3: Retrofit

- Group A: control group – no session on energy efficiency and retrofit impacts on energy consumption
- Group B: experimental group – session on energy efficiency and retrofit impacts on energy consumption

Stage 4: Retrofit and Feedback session

- Group A: control group – no session on energy efficiency and no feedback and retrofit impacts on energy consumption
- Group B: experimental group – session on energy efficiency, feedback session and retrofit impacts on energy consumption

A summary of the stages and their implementation timings can be found in Table 2.6. In each stage, the monitored data will be collected through smart meters for energy consumption assessment, and through surveys conducted to the tenants to evaluate attitudes and perceptions towards behaviour changes, comfort levels, improvement of quality of life and satisfaction towards the interventions performed. The data collected will also enable the development of tailored-made feedback reports to present to the participants.

Table 2.6: Public residential building monitoring data timeline (timeline is dependent on the retrofit intervention progress that might suffer some delays).

Stage	Data Group	Data description	2018											2019											2020										
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			...	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 - Baseline	Z	Baseline data																																	
Stage 1 - Energy Efficiency Session	A	No session (control group)																																	
	B	Energy efficiency session (experimental group)																																	
Stage 2 - Feedback session	A	No session (control group)																																	
	B	Energy Efficiency Session + feedback (experimental group)																																	
Stage 3 - Retrofit	A	No session (control group) + retrofit																																	
	B	Energy efficiency session + retrofit (experimental group)																																	
Stage 4 - Retrofit and feedback session	A	No session (control group) + retrofit																																	
	B	Energy efficiency session + retrofit + feedback (experimental group)																																	

2.2.2 Data source specifications and timeline

A set of data sources have been identified in order to be able to collect data that will enable the impacts assessment of the retrofit actions. Table 2.7 presents the data sources identified to collect the necessary data as well as the description of the data that will be monitored. In the case of the Lisbon public housing data will be collect through the following data sources:

- Energy meter: installed at building and apartment level enable monitoring energy consumption. Data on energy consumption at an apartment level will require tenants' authorization due to privacy issues. Energy meters will also collect data regarding renewable energy production and exportation. This data is dependent on the installation of PV panels.
- Building envelope thermal evaluation: two evaluations will be performed on the thermal performance of the building envelope, which will allow addressing issues of thermal comfort from the tenants
- Surveys to tenants: a socio-economic characterization survey will be performed to the participants belonging to the experimental group that will be involved in the energy efficiency educational sessions and will receive feedback on their behaviour patterns. And additional comfort survey and energy poverty assessment survey will be conducted to all habitants of the public housing unit that is being retrofitted. Nonetheless, issues related with privacy issues and willingness to answer the surveys need to be considered.
- Interviews to operators/stakeholders: these will allow assessing operators/stakeholders willingness to replicate and/or scale-up such an approach to similar buildings in the city of Lisbon.
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project
- Monitored data: concerns data that will be collected throughout the monitoring period enabling the assessing several indicators, such as performance and energy supply reliability, and the impact of weather conditions and existence of unexpected events.

Table 2.7: Public housing data sources timeline

Data Source	Data description	Month																											
			2018				2019												2020										
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Energy meter	Renewable energy produced on the building site																												
	Renewable energy produced and exported from the building site																												
	Renewable energy produced and used on site																												
	Grid electricity consumption (aggregated level)																												
	Grid electricity consumption (apartment level)	Privacy issues																											
Survey to tenants	Socio-economic characterization survey (experimental group)																												
	Comfort survey (All tenants)																												
	Energy poverty																												
Interview to Operators/ stakeholders	Willingness to retrofit																												
	Operational impacts (maintenance, revenues, business model, etc.)																												
Calculated data	CO2 footprint																												
Monitored data	Performance reliability (repairs)																												
	Energy supply reliability (frequency of blackouts)																												
	Weather conditions (temperature and solar radiation)																												
	Unexpected events																												

2.2.3 Partners and responsibilities

Instituto Superior Técnico (IST) was involved in the design of the monitoring plan for public housing buildings within the Sharing Cities program. As such, IST will contribute and participate in all the stages defined for the monitoring and evaluation program, namely in citizen engagement activities, development of energy efficiency educational sessions, feedback reports to participants, surveys design and data analysis. Additionally, IST will analyse the data collected from other partners throughout the monitoring period.

Municipality of Lisbon (CML) is the owner of the public housing unit selected to be retrofitted within the Sharing Cities program. The CML selected the building to be retrofitted and was responsible for the procurement process, definition of the retrofit measures to apply on the buildings, selection and supervision of the contractor that will perform the interventions defined. Furthermore, CML also contributed to the definition of the monitoring plan. Finally, CML is responsible for the data storage, and for the data privacy. Additionally, CML will also facilitate the implementation of the monitoring plan defined, that requires a close collaboration with the neighbourhood local associations and the active engagement of the tenants.

Lisboa E-Nova (LBN) is involved in the supervision of the retrofit interventions performed in the public housing units. Also, LBN has contributed to the development of the monitoring plan and will be engaged in the activities outlined in the several monitoring stages. Furthermore, LBN will also contribute for the impact analysis of the retrofit intervention performed.

EDP-Distribuição (EDP-D) is the mainland Portuguese distribution company, operating under regulatory supervision, responsible collecting data from the energy meters installed in the buildings and tenants' apartments and for providing data collected. EDPD will also be involved in several tasks related with the monitoring program, particularly in what concerns the development of the energy efficiency educational sessions that will be conducted. EDP is responsible for data privacy issues concerning access to disaggregated data (apartment level) of energy consumption.

A summary of the partners involved, responsibility per data source and data risk associated to each data source is presented in Table 2.8.

Table 2.8: Public residential building partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
Energy meters	EDP-D	EDP-D	EDP-D	EDP-D	EDP-D	EDP-D	CML	Privacy (apartment level)	Yes
Tenants Survey	IST/LBN	-	-	IST/LBN	IST/LBN -	.	IST/LBN	Privacy Willingness to answer	No
Interview to operator/ stakeholder	IST/LBN	-	-	IST/LBN	IST/LBN -	.	IST/LBN	-	No
Calculated data	IST/LBN	-	-	IST/LBN	-	.	IST/LBN	-	No
Monitored data	IST/LBN	-	-	IST/LBN	-	.	IST/LBN	-	No

2.3 Public Service Buildings

The Lisbon Municipality has selected two tertiary buildings to undergo retrofit interventions. One of these buildings is an iconic historic building for the city, the Lisbon City Hall. The intervention in this building has to overcome some constrains related to complying with current national regulations and legislation, such as the maintenance of historical traits and the protection of panoramic views. The other tertiary building selected is an elementary School in need on requalification. The retrofit actions selected for the school aim to improve the building's energy efficiency and occupants comfort. PV panels will be installed in both tertiary buildings, enabling the potential production of renewable energy which will, consequently, contribute to the overall improvement of the buildings energy performance. A summary of the retrofit actions performed in both public service buildings is presented in Table 2.9.

Table 2.9: Summary of the type of retrofit interventions for Lisbon public service buildings

Type of building	Address	Area	Type of intervention	Description of intervention
Public service	Paços do Concelho	5080 m2	Windows	Low-e glaze (8 mm) window
			Lighting	Replace lamps for LEDs
			HVAC system	Heat Pump COP=4.40, EER=4.12
			Renewable energy	100 PV pannels
	EB1 Engenheiro Duarte Pacheco	1686 m2	Insulation	Roof insulation with Sandwich pannels and mineral wool
			Windows	Double glazing laminated windows with 16mm air gap; blackouts
			Lighting	replace lamps for LEDs
			HVAC system	Gas boilder (eef=107.6%) for classrooms Multi-split (COP=3.72) for offices
			Renewable Energy	320 PV pannels

The impacts of these retrofit measures will be assessed through a monitoring plan.

2.3.1 Implementation stages & timeline

Regarding the Lisbon historical public service buildings *Paços do Concelho*, 3 monitoring stages have been identified: baseline (Stage 0), during retrofit (Stage 1) post-retrofit (Stage 2). Stage 1 is related with data collected from the building sites before any implementation of retrofit interventions. Stage 2 concerns data obtained during retrofit, since not all the measures were implemented at the same time. Finally Stage 3 concerns the collection of data after the requalification of the buildings. In each of these stages data will be collected from the several data sources identified for the impact assessment analysis. Table 2.10 presents a summary of the stages and implementation stages defined for the *Paços do Concelho* building. In each stage, the monitored data will be collected through smart meters and transmitted to the Sustainable Energy Management System (SEMS) implemented in the building for energy consumption assessment and renewable energy production and exportation. Furthermore, data will also be obtained through surveys conducted to the municipality workers for comfort and acceptance perception and through interviews conducted to operator of the systems, building manager and important stakeholders.

Similarly, the monitoring plan defined for the Elementary School also comprises 3 stages: baseline (Stage 0); post intervention – before PV (Stage 1) and; post-intervention – after PV (Stage 2). Baseline stage concerns the collection of data from the building before any retrofit intervention. Stage 1 collects data after retrofit interventions but before the installation of PV panels, while Stage 2 collects

data after requalification of the building is complete. In each of these stages data will be collected from the several data sources identified for the impact assessment analysis. Table 2.11 presents a summary of the stages and implementation stages defined for the Elementary school building. The monitored data will be collected through smart meters for energy consumption assessment and renewable energy production and exportation. Furthermore, data will also be obtained through surveys conducted to the school workers and students for comfort and acceptance perception and through interviews conducted to building operator and manager and important stakeholders.

2.3.2 Data source specifications and timeline

In order to perform an impacts assessment of the retrofit intervention, a set of data sources have been identified for both buildings. Table 2.12 and Table 2.13 present the data sources identified to collect the necessary data as well as the description of the data that will be monitored for the *Paços do Concelho* building and elementary school building respectively. In both buildings, data will be collect through the following data sources:

- Energy meter /SEMS: installed at building level enable monitoring energy consumption and renewable energy production and exports patterns. This data is dependent on the installation of PV panels. Data collected through the Sustainable Energy Management System (SEMS) deployed as another measure of Sharing Cities program (further details can be seen in section 3) will enable integrating data from energy meters installed in the building, but also data on energy produced and exported from renewable sources, electricity demand, EV charging patterns.
- Surveys to municipality workers (*Paços do Concelho*): a survey to assess workers comfort and satisfaction perception towards the retrofit interventions. Issues related with privacy issues and willingness to answer the surveys need to be considered.
- Surveys to school workers and students: a survey to assess comfort and satisfaction perception towards the retrofit interventions. Issues related with privacy issues and willingness to answer the surveys need to be considered.
- Interviews to operators/stakeholders: these will allow assessing operators/stakeholders willingness to replicate and/or scale-up such an approach to similar buildings in the city of Lisbon.
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project
- Monitored data: concerns data that will be collected throughout the monitoring period enabling the assessing several indicators, such as performance reliability

Table 2.10: Public service building monitoring data timeline – Paços do Concelho Building.

Stage	Data Group	Data description	2018									2019												2020											
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			…	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 - Baseline	Z	Baseline data																																	
Stage 1 - Retrofit	A	Post Intervention – before retrofit completed																																	
Stage 2 – Retrofit complete	B	Post intervention after retrofit intervention is completed																																	

Table 2.11: Public service building monitoring data timeline – School EB1 Engenheiro Duarte Pacheco Building.

Stage	Data Group	Data description	2018									2019												2020											
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			…	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 – Baseline	Z	Baseline data																																	
Stage 1 - Retrofit	A	Post intervention before PV																																	
Stage 2 – PV pannels	B	Post intervention after PV																																	

Table 2.12: Public service building data sources timeline – Paços do Concelho Building

Data Source	Data description	Month																													
			2018				2019												2020												
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Energy meter/ SEMS	Renewable energy produced on the building site																													
	Renewable energy produced and exported from the building site																													
	Renewable energy produced and used on site																													
	Grid electricity consumption (aggregated level)																													
Calculated data	CO2 footprint																													
Monitored data	Performance reliability (repairs)																													
Survey to workers	Comfort and satisfaction perception																													
Interview to operator/ building manager	Operational impacts (maintenance, revenues, business model, etc.)																													
Interview to stakeholders	Willingness to retrofit																													

Table 2.13: Public service building data sources timeline – School EB1 Engenheiro Duarte Pacheco Building

Data Source	Data description	Month																												
			2018				2019												2020											
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Energy meter	Renewable energy produced on the building site																													
	Renewable energy produced and exported from the building site																													
	Renewable energy produced and used on site																													
	Grid electricity consumption (aggregated level)																													
Calculated data	CO2 footprint																													
Monitored data	Performance reliability (repairs)																													
Survey to students/ teachers/ school workers	Comfort and satisfaction perception																													
Interview to operator (school management)	Operational impacts (maintenance, revenues, business model, etc.)																													
Interview to stakeholders	Willingness to retrofit																													

2.3.3 Partners and responsibilities

Instituto Superior Técnico (IST) was involved in the design of the monitoring plan for public service buildings within the Sharing Cities program. As such, IST will contribute and participate in all the stages defined for the monitoring and evaluation program. Additionally, IST will analyse the data collected from other partners throughout the monitoring period.

Municipality of Lisbon (CML) is the owner of the public service buildings selected to be retrofitted within the Sharing Cities program. The CML selected the buildings to be retrofitted and was responsible for the procurement process, definition of the retrofit measures to apply on the buildings, selection and supervision of the contractor that will perform the interventions defined. Furthermore, CML also contributed to the definition of the monitoring plan and will provide access to the workers, building managers and stakeholders for the conduct of interviews and/or surveys.

Lisboa E-Nova (LBN) is involved in the supervision of the retrofit interventions performed in the public housing units. Also, LBN has contributed to the development of the monitoring plan and will be engaged in the activities outlined in the several monitoring stages. Furthermore, LBN will also contribute in the impact analysis of the retrofit intervention performed.

EDP-Distribuição (EDPD) is the mainland Portuguese distribution company, operating under regulatory supervision, responsible collecting data from the energy meters installed in the buildings for providing data collected.

A summary of the partners involved, responsibility per data source and data risk associated to each data source is presented in Table 2.14.

Table 2.14: Public service buildings partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
Energy meters	EDP-D	EDP-D	EDP-D	EDP-D	EDP-D	EDP-D	CML	Privacy (apartment level)	Yes
Survey to students/teachers/school workers/	IST/LBN	-	-	IST/LBN	CML	.	IST/LBN	Privacy Willingness to answer	No
Interview to operator (school management)	IST/LBN	-	-	IST/LBN	CML	.	IST/LBN	-	No
Interview to stakeholders	IST/LBN	-	-	IST/LBN	CML	.	IST/LBN	-	No
Survey to workers	IST/LBN	-	-	IST/LBN	CML	.	IST/LBN	Privacy Willingness to answer	No
Interview to operator/building manager	IST/LBN	-	-	IST/LBN	CML	.	IST/LBN		No
Calculated data	IST/LBN	-	-	IST/LBN	CML	.	IST/LBN	-	No
Monitored data	IST/LBN	-	-	IST/LBN	CML	.	IST/LBN	-	No

3 LISBON SUSTAINABLE ENERGY MANAGEMENT SYSTEMS

In Lisbon the main objectives are to demonstrate the potential benefits of energy monitoring and management in public services buildings and at a building and city scale, level which will be achieved by tackling several use cases. To achieve this, a fully operational Building Energy Management System (BEMS) will be deployed as well as Sustainable Energy Planning System (SEPS) that will work at a district level. The following sections will present these two measures in more detail.

3.1 SEMS

Sustainable Energy Management Systems (SEMS) enable the integration of different energy vectors, optimisation of their operation and energy use, providing the means that support users in obtaining more information and be more efficient, after energy efficient retrofit interventions. SEMS can enable the possibility of implementing Advanced Process Control (APC), allowing for the smart integration of infrastructure and equipment to achieve optimized operation and forecast control.

In Lisbon, the SEMS will be implemented and tested in a public service building, the City Hall, that is also being considered under building retrofit interventions, as explained above (section 2.3.). The main objectives are to demonstrate the potential benefits of energy monitoring and management in public services buildings, as well as to improve and induce energy efficiency behaviours. To achieve this, three use cases will be taken into consideration:

- Lisbon UC1 – Building mounted PV, with the objective of maximizing building-level utilisation of renewable self-generation;
- Lisbon UC2 – Building energy management, with the objective of minimizing building electricity costs via load management; Local grid-connected PV micro grid management, with the objective of maximizing the use of renewables (PV) electricity generation on local grid and minimizing consumer electricity costs;
- Lisbon UC3 - Encourage effective integration of renewables and forecast features with EVs charging needs.

SEMS will ensure an optimal management of the building energy inflow, providing a full integration of building energy consumption and production, thus maximizing the use of renewables through self-consumption.

3.1.1 Implementation stages & timeline

The monitoring plan regarding the implementation of SEMS in the city of Lisbon was developed taking into account not only the deployment of the SEMS in the building but also the retrofit activities taking place in the building. As such, several stages were identified (presented in Table 3.1):

- Collection of energy consumption historical data before retrofit intervention and implementation of SEMS.

Stage 1 - Pilot

- Comprises the testing and simulation phase of the SEMS implementation

Stage 2 – Monitoring phase

- Analysis of impacts of SEMS implementation before all the retrofit activities are fully deployed,

- Analysis of the impacts of SEMS implementation after all the retrofit activities are fully deployed

3.1.2 Data source specifications and timeline

The analysis of the SEMS implementation impacts will be performed through the data collected from several data sources:

- SEMS data feed: regards all the data collected through the SEMS, particularly what concerns energy consumption and savings, energy produced and exported from renewable sources, electricity demand, EV charging patterns and its influence in the building consumption, system malfunctions
- Interview to operator(s): assess impacts of SEMS implementation on building energy management, satisfaction with SEMS, advantages and disadvantages
- Interview to decision-makers/stakeholders: evaluation of willingness to deploy SEMS in other municipal buildings and business model development and implementation changes. Furthermore, interviews to crucial stakeholders involved in Energy management of buildings will also allow to assess the impact of additional measures that have been promoted over the last years, such as the promotion of behavioural changes, in the building's performance.
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project
- Research data: regarding the evaluation of replication and/or scale of the measure in other municipal fleets and cities

A summary of the data sources, the description of data obtained from each source and a timeline of data collection is presented in Table 3.2.

Table 3.1: SEMS monitoring data timeline

Stage	Data Group	Data description	2018									2019												2020											
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			...	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 – Baseline	Z	Historical data before retrofit and SEMS																																	
Stage 1 - Pilot	A	Pilot																																	
Stage 2 – Monitoring Phase	B	Before Retrofit																																	
	C	After Retrofit																																	

Table 3.2: SEMS data sources timeline

Data Source	Data description	Month																																	
			2018				2019												2020																	
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60						
SEMS monitored data	Energy consumption																																		
	Energy savings																																		
	Energy from renewable sources																																		
	Electricity demand																																		
	EV charging																																		
	System malfunction																																		
Interviews to operator	Impacts in building energy management																																		
Interviews to stakeholders/decision-maker	Willingness to deploy and business model																																		
Calulated data	CO2 footprint																																		
Research data	Replication																																		

3.1.3 Partners and responsibilities

Table 3.3 summarizes the partners involved and the corresponding responsibilities of each partner within the SEMS deployment.

EDP-D, the Mainland Portuguese distribution company, operating under regulatory supervision, is the partner responsible for the SEMS design and implementation. As such EDP-D was responsible for setting the specifications and for procuring a third-party company that will develop, deploy and maintain the SEMS meaning that EDPD is the main responsible for setting the specifications for the SEMS-BL.

CML, the local government authority of Lisbon is the owner of the building where SEMS-BL will be implemented and, therefore, also contributed for the development of SEMS and its specifications. They are responsible for providing data on the buildings operational costs. As the building owner and manager, will be responsible for collecting and communicating the financial indicators and their privacy. CML will also be responsible for providing access to the building managers, as well as potential relevant stakeholders, for the conduct of interviews and surveys.

IST cooperated with EDP-D in the design of the SEMS specification and, as WP8 local leader is responsible for evaluating the impacts of the measure. IST will collect the data necessary to calculate and estimate the indicators that cannot be directly measured by the SEMS. is responsible for the analysis of available data that will allow assessing the impacts of the measures. IST will also be responsible for the development and the conduct of potential interview and surveys to building managers and relevant stakeholders involved in the deployment of this measure.

LBN provides support to the municipality on energy management of all municipal buildings and infrastructures, including the City Hall in which the SEMS is being implemented. Along several years, the main goal of this support is to improve energy efficiency and reduce costs. For this reason, it will supervise the progress of the activities and will contribute to the analysis of the available data, as well as for the development and conduct of interviews to be conducted within the SEMS scope.

NEW R&D – Centre for New Energy Technologies (NEW) is a joint initiative between EDP and CTG focused on Research and Development was responsible for procuring the third-party company that developed and deployed SEMS and for data storing.

Virtual Power Solutions (VPS) is the third-party company contracted by EDPD responsible for developing and deploying SEMS and of collecting and managing the data produced. VPS will send data to the USP and provide WP8 partners access to the data enabling the assessment of the SEMS impacts.

Table 3.3: SEMS partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
SEMS	CML/EDP-D	NEW	VPS	VPS	VPS	VPS	CML		Yes
Interview to operator	IST/LBN	-	-	IST/LBN		.	IST/LBN	-	No
Interview to stakeholders	IST/LBN	-	-	IST/LBN		.	IST/LBN	-	No
Calculated data	IST/LBN	-	-	IST/LBN		.	IST/LBN	-	No
Monitored data	IST/LBN	-	-	IST/LBN		.	IST/LBN	-	No

3.2 SEPS

At a city level, the main ambition is to develop a holistic integrated system, that will provide dynamic data at a city-wide level. As such, an Energy Planning System (SEPS) will be deployed in Lisbon aiming to contribute to the improvement of the city's energy behaviour and performance. The SEPS will be achieved by combining:

- place (geographical location)
- data (collected and generated information)
- integration (relationship and matching)
- visualization (user requirements)

The deployment of SEPS aims to support urban policy makers and city planners for the future definition of sustainable strategies to be applied at a city-level, promote better building energy management and the promotion of renewable energy local production. Furthermore, SEPS will also aim to engage different targets such as decision-makers, stakeholders, managers, citizens, among others in interacting and using such a tool in order to stimulate the creation of new services that have the potential of improving quality of life and, consequently, the life of the city.

3.2.1 Implementation stages & timeline

Table 3.4 presents the monitoring plan regarding the implementation of SEPS in the city of Lisbon. The monitoring plan regarding SEPS will focus on baseline data that corresponds to the period before its implementation. The second stage of this monitoring plan will take into account the impacts of SEPS on data collected at a city-level. The plan includes:

Stage 0 – Baseline

- Collection and analysis of historical data before implementation of SEPS.

Stage 1 – Deployment

- Collection and analysis of data after the implementation of SEPS

3.2.2 Data source specifications and timeline

The analysis of the SEPS implementation impacts will be performed through the data collected from several data sources:

- SEPS platform: the platform will aggregate several types of data from different sources, that range from city energy consumption and production, data quality, data analytics to user experience and characterization.
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project
- Research data: regarding the evaluation of replication and/or scale of the measure in other municipalities and/or cities, development of tools, apps and innovative businesses for city energy efficiency improvement consequent of the SEPS platform and how SEPS is used for new research
- Bills: to analyse city energy cost
- Interviews to city management: to assess the impact of SEPS in city management and development of potential services, products and policies due to its implementation

A summary of the data sources, the description of data obtained from each source and a timeline of data collection is presented in Table 3.5.

Table 3.4: SEPS monitoring data timeline

Stage	Data Group	Data description	2018									2019											2020										
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			...	M 29	M 30	M 31	M 32	M 33	M 34	M 35	M 36	M 37	M 38	M 39	M 40	M 41	M 42	M 43	M 44	M 45	M 46	M 47	M 48	M 49	M 50	M 51	M 52	M 53	M 54	M 55	M 56	M 57	M 58	M 59	M 60
Stage 0 – Baseline	Z	Baseline																																
Stage 1 – Deployment	A	After SEPS deployment																																

Table 3.5: SEPS data sources timeline

Data Source	Data description	Month																																
			2018				2019														2020													
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
SEMS monitored data	City energy consumption/production																																	
	Data quality																																	
	Data analytics																																	
	Data Coverage																																	
	Increase in incentives policies																																	
	Changes in mobility/lighting/etc. planning																																	
	Operator perception of system functionality																																	
	Perception of city energy consumption																																	
	UI/UX																																	
	User characterization																																	
Calulated data	CO2 footprint																																	
Research data	Replication																																	
	Renewable energy investment																																	
	City self-sustainability																																	
	development of tools for city energy efficiency improvement																																	
	apps and businesses created using SEPS data																																	
	Uses of SEPS in new research																																	
Bills	City energy cost																																	
Interview	City management costs																																	

3.2.3 Partners and responsibilities

Table 3.6 presents the partners involved in the deployment of SEPS and their responsibilities:

LBN is responsible for creating the specifications of SEPS along with the municipality as well as for the procurement process associated with its deployment. LBN will collect data from several sources, will communicate and store it in the platform and will be responsible for data handling and privacy issues. LBN will also play a role in the analysis of data and of further indicators needed to assess the impacts of SEPS at a city-level.

CML will also play a role in the definition of SEPS specification and will be responsible to provide information on city energy costs.

EDP-D, as the national energy distribution company, is the main source of data to be used by SEPS. For this reason, its role will be mostly related to the acquisition and collection of data, as well as to ensure the availability of these data in USP.

IST as WP8 local leader will be responsible for the analysis of the data collected through SEPS in order to assess the impacts of SEPS in all its dimensions. Furthermore, IST will also be responsible for creating specifications and analysing data that will be needed to evaluate SEPS full potential.

Table 3.6: SEPS partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
SEPS Platform	LBN/CML	LBN		LBN	EDP-D/LBN	LBN	LBN		Yes
Calculated data	IST/LBN	-	-	IST/LBN		.	IST/LBN	-	No
Research	IST/LBN	-	-	IST/LBN		.	IST/LBN	-	No
Bills									
Interviews	IST/LBN	-	-	IST/LBN		.	IST/LBN	-	No
Bills	CML			IST/LBN			IST/LBN		

4 LISBON MOBILITY DEMONSTRATORS

Lisbon Municipality has been actively engaged in implementing several measures that will contribute not only to an integrated mobility system in Lisbon but also to increase the energy efficiency of urban mobility and, consequently, the quality of life in the city of Lisbon. These measures include the promotion and deployment of sharing services (e.g. car-sharing systems, bike-sharing systems), electrification of mobility (deployment of electric vehicles and electric vehicle charging network), infrastructure for pedestrian and biking, real-time information tools, among others.

4.1 eV Car Sharing

While the municipality of Lisbon is the owner of one of the biggest EV fleet of the country, the aim of this measure is to further promote the adoption of EV within the municipality and, by extension, encourage the widespread adoption sharing principles by municipal workers and, overall, the EV technology by citizens. As such, a corporate free-floating e-car sharing scheme will be implemented within the Municipality with a total of 20 EV, supported by a smartphone app for its operation. Furthermore, supporting the e-car sharing scheme, a smart mobility platform will be implemented, enabling the monitoring and management of the fleet and providing fleet managers with important information regarding the scheme operations, vehicles usage patterns, maintenance needs, etc.

A monitoring plan was defined in order to evaluate the impacts of the introduction of this measure within the Lisbon municipality fleet.

4.1.1 Implementation stages & timeline

The monitoring plan related to the implementation of the corporate ecar sharing in the city of Lisbon was designed taking into account its characteristics and implementation stages. The monitoring plan is composed of 3 stages: baseline (Stage 0), EV sharing (Stage 1) EV sharing APP (Stage 2). In these 3 stages data will be collected in order to assess the impacts of the measure, mainly in what concerns vehicle usage, fleet management, willingness to use the system, users' satisfaction and perception and impacts on energy consumption and pollutants emissions. A summary of the stages can be found in Table 4.1:

Stage 0: baseline

- Historical data from municipal fleet: data from vehicles from municipal fleet before the deployment of the corporate ecar sharing

Stage 1: EV carsharing

- Non-shared EV: usage data from municipal fleet EVs not used within the sharing system
- Shared EV: usage data from corporate ecar sharing scheme

Stage 2: EV carsharing APP

- Non-shared EV
- Shared EV: usage data from corporate ecar sharing scheme
- Shared EV APP: usage data from corporate ecar sharing scheme and from the smart mobility platform

Table 4.1: EV carsharing monitoring data timeline

Stage	Data Group	Data description	2018									2019											2020											
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			...	M 29	M 30	M 31	M 32	M 33	M 34	M 35	M 36	M 37	M 38	M 39	M 40	M 41	M 42	M 43	M 44	M 45	M 46	M 47	M 48	M 49	M 50	M 51	M 52	M 53	M 54	M 55	M 56	M 57	M 58	M 59	M 60
Stage 0 - Baseline	Z	Historic data from municipal fleet																																	
Stage 1 – EV sharing	A	EV shared																																	
	B	EV not shared																																	
Stage 2 - Feedback session	A	EV shared																																	
	B	EV not shared																																	
	C	EV shared + APP																																	

4.1.2 Data source specifications and timeline

A set of data sources have been identified to assess the impacts of the deployment of corporate ecar sharing. These data sources as well as a description of the data they will allow collecting are presented in Table 4.2. Data will be collected through the following data sources:

- Mobility Device Connector (uMDC): with the installation of these devices developed by CEiiA it will be possible to monitor in real-time the vehicles gathering data related with vehicle usage (e.g. number of trips, duration of trips, km travelled, energy consumed and charged, etc.) from both shared and non-shared EV.
- Smart mobility platform: data from this data source is related with maintenance of vehicles
- Fleet management: enables collecting data that is not possible to collect through both the uMDC and smart mobility platform, such as number of incidents, repairs, usage of vehicle per department or type of users. These data are dependent on willingness to share data and availability of information.
- Survey: A survey conducted to the users will allow assessing attitudes and behaviours towards the scheme, advantages and disadvantages, among others
- Interview to Operator: Enables evaluating the impact of scheme deployment in fleet management, such as optimization of trips, changes in business model, procurement procedure, etc.
- Interview to decision-makers: assessing the impacts in decision-making towards the further willingness to deploy similar schemes within the municipality and potential impacts in policy-making.
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project
- Research data: regarding the evaluation of replication and/or scale of the measure in other municipal fleets and cities

Table 4.2: EV carsharing data sources timeline

Data Source	Data description	Month																														
			2018				2019												2020													
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
uMDC - Mobility device connector	Distribution of EV energy																															
	Distribution of battery charge level at hire/drop-off																															
	Vehicle usage																															
	Trips characterization																															
Smart mobility platform	Vehicle maintenance																															
	Trips characterization																															
	Users characterization																															
Fleet management	Users characterization																															
	Incident reports																															
Survey to users	Qualitative data																															
Interview to operators	Fleet management impact																															
Interview to decision-makers	Willingness to deploy																															
Calculated data	CO2 footprint																															
Research data	Replication																															

4.1.3 Partners and responsibilities

Table 4.3 presents the partners involved in the deployment of EV carsharing and their responsibilities: CML is the owner of the vehicles that will be used for the EV charsharing fleet, so their role will be to provide access to the vehicles in order to install the sensors that enable vehicle monitoring by ensuring data privacy issues. Additionally, CML will also provide data that might not be captured through the monitoring device installed in vehicles and that are related with fleet management indicators. Regarding surveys to the users of the scheme, CML will also facilitate the communication with the users for the conduct of the surveys.

CEiiA main role in this measure is to develop, provide and install the equipment necessary to monitor the vehicle usage patterns but also to collect, communicate and manage the data through a data platform. CEiiA will also develop the APP that drivers will use for vehicle usage.
As WP8 local lead, IST will be responsible for analysing the data collected in order to assess the impacts of the measure. IST will also develop and conduct potential interviews and surveys with relevant stakeholders, fleet managers, users of the scheme also within the scope of WP8 activities.

Table 4.3: EV carsharing partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
uMDC	CEiiA	CeiiA	CEiiA/CML	CEiiA	CEiiA	CEiiA	CEiiA/CML	-	Yes
Smart Mobility platform	CEiiA	CeiiA	CEiiA/CML	CeiiA	CEiiA	CEiiA	CEiiA/CML	-	Yes
Fleetmanagement	CML/IST	-	-	IST/CML	-	IST	IST	Willingness to provide data	No
Survey to users	IST	-	-	IST/CML	-	IST	IST	Willingness to answer	No
Interview to operator	IST	-	-	IST	-	IST	IST	-	No
Interview to decision-makers	IST	-	-	IST	-	IST	IST	-	No
Calculated data	IST	-	-	IST	-	IST	IST	-	No
Monitored data	IST	-	-	IST	-	IST	IST	-	No

4.2 eBike Sharing

No bike-sharing scheme existed in Lisbon when the Sharing Cities program was launched. As previously mentioned, the city of Lisbon is committed to promote the adoption of sustainable mobility behaviours, focusing on the implementation of measures supporting pedestrians and cycling. In the case of the latter, the city's priority has been to maintain and increase the cycling infrastructure, expecting to expand cycling dedicated lanes to 200 km by 2021. As such, within the Sharing Cities program and based on the Lisbon municipality strategy towards active mobility, EMEL has implemented the first bike-sharing scheme in the city of Lisbon – GIRA. The system is a station-based scheme, working in a one-way trip basis, with both conventional and electric bikes. GIRA was launched in September of 2017, with an initial 10 stations with capacity for 100 bikes. Until the end of 2020, the system plans to expand to 140 stations with a total of approximately 1400 bikes, of which 1000 will be electric. In the Lisbon Sharing Cities pilot area, around 194 ebikes have been deployed spread out in several stations, with around 700 being currently available in the whole city. Furthermore, EMEL is also planning to deploy a Park & eBike scheme, encouraging commuters to change their behaviours when moving within the city boundaries.

4.2.1 Implementation stages & timeline

The monitoring plan to assess the impacts of the deployment of a bike-sharing scheme in Lisbon takes into account several stages. These were defined according the deployment phases of the scheme and considering the new services that will be developed. Table 4.4 presents a summary of the implementation stages, data groups and timeline:

Stage 0 – baseline

- Parque das Nações area: pilot testing of the scheme

Stage 1 – Maturing

- Avenidas novas area
- Saldanha/Restauradores area
- Telheiras
- Baixa
- Full implementation area

Stage 2 – Reward Scheme (to be confirmed)

- Reallocation
- No reallocation

Stage 3 – Park & Bike

- Implementation of park & bike

Table 4.4: Ebike sharing monitoring data timeline

Stage	Data Group	Data description	2018									2019											2020											
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			...	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 - Baseline	Z	Parque das Nações area (Jun2017-Set2017)																																	
Stage 1 – Maturing phase	A	Avenidas Novas area (Dec 2017)																																	
	B	Saldanha/Restauradores (Feb 2018)																																	
	C	Telheiras (May 2018)																																	
	D	Downtown area																																	
	E	Full implementation																																	
Stage 2 – Reward Scheme (to be confirmed)	F	Reallocation	TBC																																
	G	No reallocation																																	
Stage 3 – Park & Ride	H	Park & Bike bikes	TBC																																
	I	Non Park & Bike bikes																																	

Table 4.5: Ebike sharing data sources timeline

Data Source	Data description	Month																											
			2018				2019												2020										
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Docking station	Usage patterns																												
	Amount of shared logistics																												
Open data platform	Scheme statistics																												
Surveys to users	Awareness and familiarity																												
	Behavior change																												
Interviews with operators	Impact of scheme deployment																												
Interview with decision-makers	Willingness to deploy schemes																												
Calculated data	CO2 footprint																												
Research data	Replication																												

4.2.2 Data source specifications and timeline

Data for assessing ebike sharing will be collected through several data sources, presented in

Table 4.5. These data sources include:

- Docking station: data on docking station statistics, bike usage, trips, occupation ratio, type of bike used (conventional vs electric), status, location
- Open data platform: collecting data related with scheme statistics, such as number of users, number of downloads, etc.
- Survey to users: A survey conducted to the users will allow assessing awareness and familiarity with the scheme, mobility behaviour change, advantages and disadvantages of the scheme, among others
- Interview to Operator: Enables evaluating the impact of scheme deployment, lessons learned, procurement process adopted,
- Interview to decision-makers: assessing the impacts in decision-making towards the further willingness to deploy similar schemes within the municipality and potential impacts in policy-making.
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project.
- Research data: regarding the evaluation of replication and/or scale of the measure in other municipal fleets and cities.

4.2.3 Partners and responsibilities

Table 4.6 presents the partners involved in the deployment of ebike sharing and their responsibilities: EMEL as the owner of the Ebike Sharing scheme will have the main role of managing the scheme and, as such, of providing the data that will allow evaluating and analysing the impacts of the measure. EMEL was responsible for all the process of the scheme deployment, ranging from the procurement process, installation of the bikes and docking stations to collecting, storing and communicating data. EMEL will, additionally, collaborate in the conduct of potential surveys and interviews with users of the scheme and operators in order to assess indicators such as satisfaction with the scheme, management challenges, among others.

As WP8 local lead, IST will be responsible for analysing the data collected in order to assess the impacts of the measure. IST will also develop and conduct potential interviews and surveys with relevant stakeholders, fleet managers, users of the scheme also within the scope of WP8 activities.

Table 4.6: Ebike Sharing partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
Docking station	EMEL	EMEL	EMEL	EMEL	EMEL	EMEL	EMEL	-	Yes
Open data platform	EMEL	EMEL	EMEL	EMEL	EMEL	EMEL	EMEL	-	Yes
Survey to users	IST	-	-	IST/EMEL	-	IST/EMEL	IST	Willingness to answer	No
Interview to operator	IST	-	-	IST/EMEL	-	IST	IST	-	No
Interview to decision-makers	IST	-	-	IST	-	IST	IST	-	No
Calculated data	IST	-	-	IST	-	IST	IST	-	No
Research data	IST	-	-	IST	-	IST	IST	-	No

4.3 Shared eLogistics

Besides promoting the adoption of electric vehicles by its workers within the municipality, Lisbon is also engaged in making the transition from conventional to electric vehicles in an urban logistics context. Within the Sharing Cities program, the Lisbon municipality will deploy 140 EVs, in a leasing process, that will be used for urban logistic services (vehicle dedicated to one worker for working purposes usage) and has already acquired (self-funded) 10 eVans that will be used in different municipal services for urban logistic purposes. A smart mobility platform developed by CEiiA has been implementing to help vehicle usage management.

4.3.1 Implementation stages & timeline

The monitoring plan related to the implementation of the municipal elogistics composed of 3 stages: baseline (Stage 0), EV logistics (Stage 1). A third stage might be included: EV logistics APP (Stage 2), in case there is confirmation that an APP will also be developed for elogistics purposes. EV logistics APP (Stage 2). In these 3 stages data will be collected in order to assess the impacts of the measure, mainly in what concerns vehicle usage, fleet management, willingness to use the vehicle, users' satisfaction and perception and impacts on energy consumption and pollutants emissions. One other aspect to take into consideration is the availability of eVans data, that at this moment in time, is still not confirmed. A summary of the stages can be found in Table 4.7:

Stage 0: baseline

- Historical data from municipal fleet: data from vehicles from municipal fleet before the renovation of the EV fleet (newer vehicles, more autonomy, etc.)

Stage 1: EV logistics

- EV public service: usage data from EV public service
- EVan: usage data from eVans used in different municipal services (to be confirmed)
- EV shared usage: usage data from municipal electric vehicle fleet

Stage 2: EV logistics APP (to be confirmed)

- EV public service: usage data from municipal fleet EVs not used within the sharing system
- Evan: usage data from evans used in different municipal services
- EV shared usage: usage data from municipal electric vehicle fleet
- EV public service APP: usage data from EV public service and from the smart mobility platform
- Evan APP: usage data from evans used in different municipal services and from the smart mobility platform

4.3.2 Data source specifications and timeline

A set of data sources have been identified to assess the impacts of the deployment of elogistics. These data sources as well as a description of the data they will allow collecting are presented in Table 4.8. Data will be collected through the following data sources:

- Mobility Device Connector (uMDC): with the installation of these devices developed by CEiiA it will be possible to monitor in real-time the vehicles gathering data related with vehicle usage (e.g. number of trips, duration of trips, km travelled, energy consumed and charged, etc.) from both elogistic vehicles and from eVans (data collected from eVans with the uMDC still needs to be confirmed due to privacy issues. In case it will not be possible to ensure data from uMDC,

information on eVan usage patterns will be collected through fleet manager, through interviews or requests for information)

- Smart mobility platform: data from this data source is related with maintenance of vehicles
- Fleet management: enables collecting data that is not possible to collect through both the uMDC and smart mobility platform, such as number of incidents, repairs, usage of vehicle per department or type of users. These data are dependent on willingness to share data and availability of information.
- Survey: A survey conducted to the users will allow assessing attitudes and behaviours towards the scheme, advantages and disadvantages, among others
- Interview to Operator: Enables evaluating the impact of scheme deployment in fleet management, such as optimization of trips, changes in business model, procurement procedure, etc.
- Interview to decision-makers: assessing the impacts in decision-making towards the further willingness to further deploy EV within the municipality for urban logistic purposes and potential impacts in policy-making.
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project.
- Research data: regarding the evaluation of replication and/or scale of the measure in other municipal fleets and cities.

Table 4.7: Elogistics monitoring data timeline

Stage	Data Group	Data description	2018									2019												2020											
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 - Baseline	Z	Historical data from municipal fleet																																	
Stage 1 – EV logistics	A	EV public service																																	
	B	Evan																																	
	C	EV shared use																																	
Stage 2 – EV logistics APP (to be confirmed)	E	EV public service																																	
	F	Evan																																	
	G	EV shares use																																	
	H	Evan + APP																																	
	I	EV shares use																																	

Table 4.8: Elogistics sharing data sources timeline

Data Source	Data description	Month																																	
			2018				2019																	2020											
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
uMDC - Mobility device connector	Distribution of EV energy																																		
	Distribution of battery charge level at hire/drop-off																																		
	Vehicle usage																																		
	Trips characterization																																		
Smart mobility platform	Vehicle maintenance																																		
	Trips characterization																																		
	Users characterization																																		
Fleet management	Users characterization																																		
	Incident reports																																		
Survey to users	Qualitative data																																		
Interview to operators	Fleet management impact																																		
Interview to decision-makers	Willingness to deploy																																		
Calculated data	CO2 footprint																																		
Research data	Replication																																		

4.3.3 Partners and responsibilities

Table 4.9presents the partners involved in the deployment of Elogistics and their responsibilities:

CML is the owner of the vehicles that will be used for the Elogistics fleet, so their role will be to provide access to the vehicles in order to install the sensors that enable vehicle monitoring by ensuring data privacy issues. Additionally, CML will also provide data that might not be captured through the monitoring device installed in vehicles and that are related with fleet management indicators. Regarding surveys to the users of the scheme, CML will also facilitate the communication with the users for the conduct of the surveys.

CEiiA main role in this measure is to provide and install the equipment necessary to CEiiA main role in this measure is to provide and install the equipment necessary to monitor the vehicle usage patterns but also to collect the data and manage the data through a data platform.
As WP8 local lead, IST will be responsible for analysing the data collected in order to assess the impacts of the measure. IST will also develop and conduct potential interviews and surveys with relevant stakeholders, fleet managers, users of the scheme also within the scope of WP8 activities.

Table 4.9: Elogistics Sharing partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
uMDC	CEiiA	CEiiA	CEiiA/CML	CEiiA	CEiiA	CEiiA	CEiiA/CML	-	Yes
Smart Mobility platform	CEiiA	CEiiA	CEiiA/CML	CEiiA	CEiiA	CEiiA	CEiiA/CML	-	Yes
Fleet management	CML/IST	-	-	IST/CML	-	IST	IST	Willingness to provide data	No
Survey to users	IST	-	-	IST	-	IST	IST	Willingness to answer	No
Interview to operator	IST	-	-	IST	-	IST	IST	-	No
Interview to decision-makers	IST	-	-	IST	-	IST	IST	-	No
Calculated data	IST	-	-	IST	-	IST	IST	-	No
Research data	IST	-	-	IST	-	IST	IST	-	No

4.4 eV Charing Points

Given the investment and engagement in promoting EV adoption, leading to an increase demand of EV in Lisbon, another one of the city's priorities is to grow the charging infrastructure available for users. As such, the aim of this measure is to increase the number and availability of EV charging points in the city. Within the Sharing Cities program, the municipality is installing 22 new charging points that will be available exclusively by the municipal fleet, supporting the increase introduction of EV in the fleet for operational purposes, such as corporate ecar sharing and urban logistic services. Additionally, 1 semi-fast charging station and 1 fast charging stations will be installed within the public network and available to all users. These two charging stations will be integrated in MOBI-E platform, enabling charging optimization.

4.4.1 Implementation stages & timeline

The implementation stages regarding the deployment of EV charging points in the city of Lisbon considers the different types of charging points that will be installed as well as the new services and tools that will be launched. As such, 3 implementation stages were identified (Table 4.11): baseline (stage 0), Charging points (Stage 1) and Services Stage 2). Each of these stages have different data groups associated, in which data will be collected for impacts assessment purposes, mainly in what concerns usage patterns: energy charged, duration of charges, among others.

Stage 0: Baseline

- Historical data: collection of historical data usage on usage of charging points already installed in the city of Lisbon
- EVCP CML: historical data of municipal charging points previously installed for municipal usage

Stage 1: Charging Points

- CML EVCP-Fast: data collected from the fast charging points installed by the municipality for exclusive use of the municipal fleet
- CML EVCP-Semi-fast: data collected from the semi-fast charging points installed by the municipality for exclusive use of the municipal fleet
- CML EVCP-Normal: data collected from the charging points installed by the municipality for exclusive use of the municipal fleet
- EDPD Private: data collected from the charging points installed by EDPD for exclusive use of its fleet
- EDPD Public: data collected from EDPD's public charging points network
- EDPD Public-Fast: data collected from EDPD's public fast charging points
- Public EVCP: data collected from the public network of charging points available to all users

Stage 2: Services

- Fees implementation: assessment of the impact of charging fees implementation on public charging points usage
- New APP: impacts of new app launch on public charging points usage patterns

4.4.2 Data source specifications and timeline

The impacts assessment of the deployment new charging points for both private and public usage will be performed through several data sources. Table 4.12 presents these data sources as well the data associated to them. The following data sources were identified:

- Mobi.me: through CEiiA's intelligent platform that gather MOBI.E data and provides integrated and user-centric management of mobility and energy services, data on usage profile of the charging points will be collected (historical data, private and public charging points): energy charged, duration of charges, fees, maintenance, etc.
- Interview to Operator: Enables evaluating the impact of scheme deployment in fleet management, maintenance, operational costs, etc.
- Interviews to owners of EVCP: will enable assessing the business models adopted by each owner and also how the impact that recent charging fees had on their business model, etc..
- Interview to decision-makers: assessing the impacts in decision-making towards the further willingness to further deploy EVCP within in both private and public contexts
- Calculated data: environmental impacts, particularly CO2 footprint, will be analysed through calculated data over the course of the project.
- Research data: regarding the evaluation of replication and/or scale of the measure in other municipal fleets and cities.

4.4.3 Partners and responsibilities

The partners and respective responsibilities related with EVCP are presented Table 4.10.

CEiiA main responsibility is related with the Mobi.me platform from which the data on usage profile of the EV charging points will be collected. CEíiA was responsible for creating the specifications, collecting, storing and communicating the data.

EMEL is the operator of EVCP and therefore, their main responsibility will be, aside from operating te EVCP, to share and communicate data to the MOBI.E platform. EMEL will also participate in the conduct of surveys to assess EVCP deployment.

As WP8 local lead, IST will be responsible for analysing the data collected in order to assess the impacts of the measure. IST will also develop and conduct potential interviews and surveys with relevant stakeholders, fleet managers, users of the scheme also within the scope of WP8 activities.

Table 4.10: EVCP partners and responsibility per data sources

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
Mobi.me	CEiiA	-	-	EMEL/CEiiA	EMEL/CEiiA	CEiiA	CEiiA/CML	-	Yes
Interview to operator	IST	-	-	IST	-	IST	IST	-	No
Interview to decision-makers	IST	-	-	IST	-	IST	IST	-	No
Calculated data	IST	-	-	IST	-	IST	IST	-	No
Research data	IST	-	-	IST	-	IST	IST	-	No

Table 4.11: EVCP monitoring data timeline

Stage	Data Group	Data description	2018									2019													2020										
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			...	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 - Baseline	Z	Historical data from municipal fleet																																	
	Y	CML EVCP																																	
Stage 1 – Charging points	A.1	CML EVCP – Fast																																	
	A.2	CML EVCP – Semi-fast																																	
	A.3	CML EVCP - Normal																																	
	B.1	EDP Private																																	
	B.2	EDP Public																																	
	B.3	EDP Public - fast																																	
	C	Public EVCP																																	
Stage 2 – Services	D	Fees implementation														TBC																				
	E	New APP														TBC																				

Table 4.12: EVCP data sources timeline

Data Source	Data description	Month																																
			2018				2019														2020														
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60					
Mobi.e - Previous data	usage profile																																	
Interview to operator	Impacts in fleet management and operationalization																																	
Interviews to decision-makers	Willingness to deploy																																	
Calculated data	CO2 footprint																																	
Research data	Replication																																	

4.5 Smart Parking

Within the Sharing Cities program, the city of Lisbon, through one of the project partners EMEL, will test different smart parking solutions and technologies. The main objective of this measure is to assess its feasibility and operability and, consequently, its role in the implementation of parking smart managing solutions and tools. A total of 125 smart parking sensors will be installed in two streets of the city of Lisbon, and initial tests will be carried. These smart parking solutions have the potential of improving parking management services, improve driver experience and satisfaction, savings in energy consumption and reduce pollutants emissions as well as noise emissions.

4.5.1 Implementation stages & timeline

Given that the main objective of this measure is to measure its feasibility and operability in the city of Lisbon, the implementation stages were defined taking this aspect into consideration. As such the following implementation stages and associated data groups were identified:

Stage 0 – Definition

- Procurement
- Selection of technologies and suppliers
- Installation of sensors

Stage 1 – Proof of concept

- Camera sensors: testing feasibility and operability
- Surface-mounted sensors: testing feasibility and operability

Stage 2 – Assessment

- Impacts on parking management: assessment of the potential impacts of smart parking sensors in parking management services.
- Development of new tools and services: analysis of the impacts of smart parking in the future development of new/or improved tools (e.g. APPs, etc.) and services (e.g. dynamic pricing, etc.)

Stage 3 – Scale-up

- Based on the results obtained from the installation of the Smart Parking sensors, analyse the scale-up process, mainly in what concerns the main factors motivating the scale-up and the decision-making process as well as their economic and financial impact.

A summary of implementation stages and corresponding timeline can be seen in Table 4.14.

4.5.2 Data source specifications and timeline

Data will be collected through several data sources, presented in
Table 4.15 along with a description of associated data:

- EMEL Platform: EMEL's platform will allow collecting real-time data regarding the smart parking tests, such as occupied/unoccupied parking place, average parking time, among others
- Surveys to citizens: assessment of awareness of smart parking and familiarity with the service available in the streets.

- Interviews with operators: assessment of the impact of smart parking tests in parking management and on the potential development of new and/or improved tools and services
- Interviews with decision-makers: assessment of willingness to scale-up the deployment of smart parking in the city of Lisbon, impacts on regulation and policy development
- Research data: research on smart parking market availability throughout the project duration, replication of the measure in other cities.

4.5.3 Partners and responsibilities

Regarding Smart Parking activities, the partners involved and main responsibilities are presented in Table 4.13.

EMEL main responsibilities were to create the specifications of the for the smart sensors to be installed, as well as for the procurement and installation of the sensors. The smart parking sensor are connected to the EMEL platform which collects, communicates and stores the data. EMEL is responsible for giving access to data in order to allow the analysis of the impacts of the measure.

As WP8 local lead, IST will be responsible for analysing the data collected in order to assess the impacts of the measure. IST will also develop and conduct potential interviews and surveys with relevant stakeholders and operator within the scope of WP8 activities.

Table 4.13: Smart Parking partners and responsibility per data sources

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
EMEL Platform	EMEL	EMEL	EMEL	EMEL	EMEL	EMEL	EMEL	-	Yes
Surveys to users	IST	-	-	IST	-	IST	IST	-	No
Interviews with operators	IST	-	-	IST	-	IST	IST	-	No
Interviews with decision-makers	IST	-	-	IST	-	IST	IST	-	No
Research data	IST	-	-	IST	-	IST	IST	-	No

Table 4.14: Smart Parking monitoring data timeline

Stage	Data Group	Data description	2018									2019												2020											
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			...	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 - Baseline	A.1	Procurement																																	
	A.2	Selection																																	
	A.3	Installation																																	
Stage 1 – Proof of concept	A.1	Camera sensor																																	
	A.2	Surface mounted sensors																																	
Stage 2 – Assessment	B	Impacts on parking management																																	
	C	Development of new tools and services																																	
Stage 3 – Scale-up	D	Assessment of scale-up process																																	

Table 4.15: Smart Parking data sources timeline

Data Source	Data description	Month																															
			2018				2019																	2020										
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
EMEL Platform	Real-time data																																
Surveys to users	Awareness and familiarity																																
Interviews with operators	Impacts in parking management																																
Interviews with decision-makers	Willingness to scale-up, impacts on regulation and policy																																
Research data	Market availability																																
	Replication																																

5 LISBON SMART LAMPPOSTS

5.1 Smart Lamppost Sensors

With the ambition to reduce energy consumption, the city of Lisbon will install 76 boxes composed by several sensors to monitor environmental, noise, traffic, air quality and weather indicators. These will allow testing and assessing the feasibility of additional services that can be integrated in lamppost and, consequently, contribute to the development of new urban services related to city management.

5.1.1 Implementation stages & timeline

The deployment of Smart Lampposts in the city of Lisbon involves mainly the installation of environmental, noise, traffic, air quality and weather sensors to assess their feasibility for the future development of new services and products. The implementation stages were defined according to two different use cases with several data groups associated (Table 5.1):

Stage 0 – Baseline

- Historical data collected from previous sensors
- Historical data on energy consumption

Stage 1 – Proof of concept

- Camera sensors: testing feasibility and operability
- Surface-mounted sensors: testing feasibility and operability

5.1.2 Data source specifications and timeline

Data will be collected through several data sources, presented in Table 5.1Table 5.2 along with a description of associated data:

- Data pre treatment: will allow to test if sensors are successfully working, analysing aspects related with quality of the data pre treatment, such as missing data sets, rejected data, rejected date due to sporadically events
- Lamppost sensor: after treatment data collected from the several sensors installed – environmental, weather, air quality, noise and traffic
- Surveys: assessment of awareness of existing data collected from the 5 different types of sensors and how it can be useful for the improvement of city life
- Interviews with operators: assessment of the impact of sensors in management of this type of data and its potential impact on the development on city strategies
- Research data: market research regarding availability of the sensors used, on new applications of urban data consequence of the installation of such sensors, and on the development of new and adapted policies, among others
- Collected data: regarding the demonstrator success, analysing indicators such as access to data, download volume of data, etc.

Table 5.1: Smart Lampposts sensors monitoring data timeline

Stage	Data Group	Data description	2018											2019											2020										
			Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			…	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48	M49	M50	M51	M52	M53	M54	M55	M56	M57	M58	M59	M60
Stage 0 - Baseline	Z	Baseline AminhaRua running																																	
Stage 1 – Mnitoring	A	Sensor within pilot area																																	
	B	Sesnors outside pilot area																																	

Table 5.2: Smart Lampposts sensors data sources timeline

Data Source	Data description	Month																																	
			2018				2019														2020														
		Before	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60					
Data pre treatment	Data quality																																		
LED LAMPS	Energy Data																																		
Lamppost sensor	Air quality data; environmental data; traffic data, noise emission data																																		
Surveys	Awareness																																		
Interviews to stakeholders	Operator perception																																		
Market research	Market availability; New services and tools, urban policies																																		
Collected data	Demonstrator success																																		

5.1.3 Partners and responsibilities

Table 5.3 presents partners involved in the measure Smart Lamppost Sensors and their responsibilities.
LBN is responsible for creating the specifications of the sensors to be installed, as well as for collecting data, communicating and storing data. Furthermore, LBN will also play a role in the pre-treatment data, creating the specifications, along with IST, for this analysis. Regarding data that will be collected beyond the sensor and market research, LBN will also contribute for their specifications, communication, collection and storage.

CML will be responsible for the procurement process related with the sensors to be installed.

IST, as WP8 local leader, will be responsible for analysing the data collected in order to assess the impacts of the measure. IST will also develop and conduct potential interviews and surveys with relevant stakeholders and operator within the scope of WP8 activities. Furthermore, IST will also be involved in the analysis of data collected beyond the sensors and of market research analysis.

Table 5.3: Smart Lamppost sensor partners and responsibility per data sources

Data source	Monitoring responsibilities							Data risk	Available USP
	Create specifications	Procurement	Install sensors	Collect data	Communicate data	Store data	Handle data privacy		
Data pre treatment	LBN; IST	-	-	LBN	LBN	LBN	LBN		No
Lamppost sensor	LBN	CML	?	LBN	LBN	LBN	LBN	-	Yes
Surveys	IST	-	-	IST	-	IST	IST	-	No
Interviews to stakeholders	IST	-	-	IST	-	IST	IST	-	No
Market research	IST; LBN	-	-	IST; LBN	-	IST; LBN	IST; LBN	-	No
Collected data	IST			IST	LBN	LBN	LBN		No

6 GREENWICH BULDINGS RETOFIT AND SEMS

As part of the Sharing Cities project the Royal Borough of Greenwich is retrofitting the Ernest Dence estate located on Old Woolwich Road, Greenwich, London and the Flamsteed estate on Blackwall Lane, Greenwich, London. Both sites are social housing estates, however the measures incorporated in each retrofit are very different, and therefore are considered separately.

6.1 Ernest Dence Estate

Ernest Dence estate is a solid brick construction of three 5-storey buildings built in 1937, housing 95 dwellings. A recent renovation took place to introduce two elevator shafts and merge horizontally the buildings.

Table 6.1: Ernest Dence estate blocks and features

Block	Postcode	N of flats	N Storeys
Aylmer		55	5
Jennings		20	5
Gifford		20	5
Community centre		0	1

Figure 6.1: Aerial photo of Ernest Dence estate

Dwellings heating at Ernest Dence is provided through three communal gas boilers. Radiator systems are in place in each dwelling with turning valves for heating control. In practice, it has been observed that residents find it easier to open a window rather than use the valves to reduce heat intake. The retrofit actions aim to deliver a substantial reduction of energy needs, providing at the same time, adequate thermal comfort conditions for occupants. The improvement of the buildings envelope and the replacement of the service systems with new and more efficient ones, are therefore core actions of this demonstrator.

The retrofit actions in Ernest Dence estate can be divided into three categories as per the Sharing Cities demonstrator they belong into: Retrofit, Demand Side Response (DSM) and Smart Energy Management System (SEMS). The type and scale of each retrofit action is summarized in Table 6.2.

Table 6.2: Summary of Ernest Dence estate retrofit measures and scale

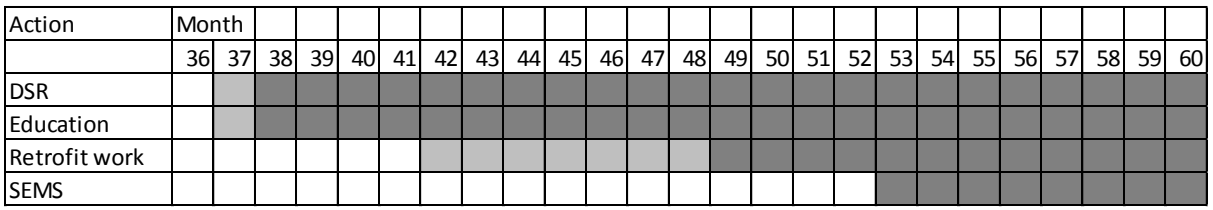
	Measure	Scale	Implementation timeline
Retrofit	Roof insulation	3 blocks	Works May-Dec 2019
Retrofit	Communal LED lighting	3 blocks	Works May-Dec 2019
Retrofit	Aesthetic work done	3 blocks	Works May-Dec 2019
Retrofit	Windows repair	3 blocks	Works May-Dec 2019
Retrofit	Electric heat pump + with backup new gas boiler and thermal storage (borehole system)	Communal for 3 blocks	Works May-Dec 2019
Retrofit	Secondary site upgrades (old pipe work upgrade (to improve insulation and routing), new radiators & heat interface units in each flat (for control)	3 blocks	Works May-Dec 2019
Retrofit	Education (residents learn to use the systems)	N/A	By Dec 2018
DSM	Demand Side Response	About 10 dwellings (100 in total in RBG)	Install by March 2019
SEMS	Optimisation of hybrid WSHP & gas boiler system	N/A	Software ready. Awaiting hardware installation.

The aim of the roof insulation, windows repair and secondary site upgrades actions are to reduce heat loss in the estate. The aim of LED lighting is to reduce electricity use. The WSHP and gas boiler upgrade aim to make heat provision more efficient. The DSR, residents education and secondary site upgrades aim to improve resident attitude towards energy efficiency. The SEMS action aims to optimise heat provision efficiency (in terms of cost and emissions) using data from dwelling, system and external data sources.

6.1.1 Implementation stages & timeline

The Ernest Dence estate site of the public housing building retrofit demonstrator of RBG consists of the following implementation stages (as shown in Figure 6.2 with respect to temporal data collected:

- Stage 0 (up to December 2018): Baseline/ pre-retrofit data
- Stage 1 (Dec 2018 to April 2019): DSR installation and activation and resident energy sustainability training
- Stage 2 (May 2019 to Dec 2019): Undertaking of retrofit activities
- Stage 3 (April 2019 to December 2020): Activation and operation of SEMS
- Stage 4 (after Jan 2020): Post-retrofit activities data



- **Figure 6.2:** Ernest Dense monitoring timeline

The Ernest Dence estate retrofit implementation involves several actions that are gradually being implemented. Therefore, the start and end dates of each action do not coincide. A challenge is to

enable the evaluation of the overall impact of the retrofit activities but also as separate actions. To achieve that two approaches are adopted:

1. temporal separation, and/or
2. establish & monitor control groups (not receiving a specific action)

As described in Table 6.2, of the 95 dwellings in 3 blocks, it is anticipated that all will be influenced by insulation upgrades, windows replacement, heating system upgrade to WSHP hybrid with a gas boiler and SEMS. Up to 100 dwellings will be involved in the DSR trial where temperature and humidity sensors will be installed. To comprehensively evaluate all types of interventions the monitoring coverage described in Table 6.3 is proposed.

Table 6.3: RBG Ernest Dence estate building retrofit demonstrator data groups

Temporal stages	Data Group ID	Training	DSR	EWI + Roof + Windows & Gas WSHP + Boiler + LED + Secondary upgrades + Aesthetic work	SEMS	Number of dwellings
0	1	N/A	N/A	N/A	N/A	95
1	2	Yes	Yes	N/A	N/A	30
			No	N/A	N/A	30
	3	No	Yes	N/A	N/A	20
			No	N/A	N/A	15
2	4	Yes	Yes	Yes	N/A	30
	5		No			30
	6	No	Yes			20
	7		No			15
3	8	Yes	Yes	Yes	Yes	30
	9		No			30
	10	No	Yes			20
	11		No			15

6.1.2 Data source specifications and timeline

To assess the impacts of retrofit, SEMS and DSR actions to Ernest Dence estate heating performance, the monitoring plan proposed covers data collection on communal and dwelling energy use, and the residents perception on aesthetics and comfort aspects. Ernest Dence estate performance is evaluation before, during and post-retrofit activities implementation, using a set of data sources that are listed in in Table 6.4.

Communal energy use

Communal electricity: A communal electricity meter to measure pre-retrofit and post-retrofit communal electricity consumption at each block. The data are to be collected manually in monthly intervals and dynamically where possible. This will show the impact of communal LED lighting. Communal gas use: Pre- and post-retrofit communal electricity consumption at each block. The data are to be collected manually in monthly intervals and dynamically where possible. WSHP energy use for heating: Data on the performance of the WSHP include water flow rate (°C), water flow temp (°C), heat rate. Thermal imaging of all 3 blocks. Measured pre and post retrofit.

Dwelling energy use

Dwelling heat demand: Pre retrofit data include temperature, humidity and light while post-retrofit data include room temperature (°C), room set temperature (°C), heat use (°C), radiator set temperature (°C) and humidity (subject to GDPR/ procurement). Live data collected pre- and post-

retrofit. Survey capturing information on electricity & gas bills/ electricity & gas meters and energy related attitudes. Also capturing level of comfort, perception on aesthetic works. Residents are invited to take part in demand side Response events. Data provided are: Electricity use in dwelling (kWh), demand side response events (time; type), temperature (°C), humidity (% relative humidity), occupancy (binary).

Covariate control data

- Local weather station data including data on external climatic conditions in terms of temperature, relative humidity, solar radiation, etc.
- Implementation masterplan per block and dwelling indicating start and end dates of each action.
- Building & apartment area, outdoor & indoor wall surface areas, orientation, window area
- Energy tariffs
- Grid carbon factor
- Age and data specs of old communal boilers.
- Residents social demographics (e.g. household type, household income, education, occupation)

6.1.3 Partners and responsibilities

The **Royal Borough of Greenwich (RBG)** is the public authority building owner of the public residential building. RBG coordinates the overall activities of the project and is the responsible for the design of the deep retrofit intervention on public buildings. RBG is responsible for the procurement process and has identified the contractor who will install the equipment under its supervision. Finally, RBG is responsible for making data available (in line with GDPR) either through data being stored in the London City data Store, or through another medium such as direct communication.

Sharing Cities WP8 (SC8) contributed to the design activities and to the definition of the pre- and post-retrofit energy and comfort monitoring plan for public buildings. Moreover, it participates in monitoring and analysis of data received during the pre- and post-intervention, it analyses all the data that other partners collect and make available through the Sharing Cities project databases.

Kiwi Power is responsible for installing the dwelling electricity meters (and in some cases plug meters) and temperature and humidity sensors.

Greater London Authority (GLA) responsible for storing the data as part of the London Datastore, and granting access to demonstrator partners.

Table 6.4: Ernest Dence estate retrofit data timeline

Data Source	Month																									
	Before	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	After
Communal electricity																											
Communal gas																											
WHSP data																											
Resident survey																											
Resident heat use																											
Thermal imaging																											
DSR data																											
Covariate data																											

Table 6.5: Ernest Dence partners role per data source

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect other data	Communicate data	Store data	Handle data privacy	
Communal electricity	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Communal gas	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
WHSP data	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Residents survey	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Dwelling comfort	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Thermal imaging	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
DSR data	SC8	RBG	Kiwi	SC8	Kiwi	GLA	RBG	-
Covariate data	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-

6.2 Flamsteed Estate

As part of the Sharing Cities project the Royal Borough of Greenwich is retrofitting Flamsteed estate on Blackwall Lane, Greenwich, London. Flamsteed estate is composed of 9 blocks of 2-4 storey buildings, housing 172 dwellings of various sizes. Flamsteed estate is a solid brick construction built in 1938.

Table 6.6: Flamsteed estate blocks and features

Block	Postcode	N of flats	N Storeys
Baldrey	SE10 0EY	20	4 (2)
Christie	SE10 0EZ	12	3
Collins	SE10 0HA	12	3
Halley	SE10 0HD	12	3
Cliffe	SE10 0RB	14	4
Dyson	SE10 0RD	72	4
Kepler	SE10 0HF	12	3
Lockyer	SE10 0HB	10	2

Figure 6.3: Flamsteed estate aerial photo

Heating for 8 of 9 blocks is provided by individual gas boilers at each apartment while at "Lockyer House" block the are no boilers and heating is provided by an underfloor electric system, frequently complemented by residents own means. The retrofit actions aim to deliver a substantial reduction of energy needs, providing at the same time, adequate thermal comfort conditions for occupants. The improvement of the buildings envelope and the replacement of the service systems with new and more efficient ones, are therefore core actions of this demonstrator. The type and scale of each retrofit action is summarized in Table 6.7.

Table 6.7: Summary of Flamsteed estate retrofit measures and scale

Measure	Scale
External wall insulation (EWI)	9 blocks
Roof insulation	9 blocks

Windows replacement	9 blocks
Solar panels (communal use + grid)	8 blocks (1002 modules/ 270.54kWp)
Communal LED lighting	9 blocks
Replacement of old boilers, piping & radiators	80 systems (where applicable out of 8 blocks)
Installation of gas boiler, piping & radiators	Lockyer House
Demand Side Response	About 10 dwelling (100 in total in RBG)

To properly assess the impacts of the retrofit actions on the building performance, the monitoring plan proposed covers energy and comfort aspects.

6.2.1 Implementation stages & timeline

The Flamsteed estate site of the public housing building retrofit demonstrator of RBG consists of the following implementation stages with respect to temporal data collected:

- Stage 0 (up to November 2018): Baseline/ pre-retrofit data
- Stage 1 (Jan 2019 to May 2019): DSR and Education of residents
- Stage 2 (June 2019 to Dec 2019): During retrofit activities data
- Stage 3 (after Jan 2020): Post-retrofit activities data

The Flamsteed estate retrofit implementation will be gradual, meaning that the start and end dates of the retrofit will change for various estate blocks, starting with a 'showcase' block will be completed as a priority to enable a more extensive post-retrofit evaluation. An additional challenge is to enable the evaluation of the overall impact of the retrofit activities but also as separate actions. As described in Table 6.7, of the 172 dwellings it is anticipated that all will be influenced by insulation upgrades and windows replacement. All Lockyer House dwellings will be influenced by boiler system installation (replacing underfloor heating). About half of the rest of the dwellings will be influenced by gas boiler upgrade (replacing old boilers). About 10 dwellings will be involved in the DSR trial where temperature and humidity sensors will be installed. To comprehensively evaluate all types of interventions the monitoring coverage described in Table 6.8 is proposed.

Action	Month																							
	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
DSR																									
Education																									
Retrofit work																									

Table 6.8: RBG Flamsteed estate building retrofit demonstrator data groups

Data Group	EWI + Roof + Windows	Gas boiler (replace)	Gas boiler (install)	DSR	Number of dwellings
1	Yes	Yes	No	Yes	At least 10
2				No	-
3		No	Yes	Yes	At least half Lockyer House dwellings
4				No	-
5		No	No	Yes	-
6				No	-

6.2.2 Data source specifications and timeline

To evaluate the performance of the specific site before and after the demonstrator implementation, as set of data sources have been identified that are listed in Table 6.10.

Communal energy use

Solar panels: An electricity meter to measure solar panel production and an electricity meter to measure amount sold to grid. The action is only evaluated post-retrofit. Live data available. Communal LED lighting: A communal electricity meter to measure pre-retrofit and post-retrofit communal electricity consumption at each block. The data are to be collected manually in monthly intervals. Thermal imaging of all blocks. Captured pre and post retrofit.

Dwelling energy use

Dwelling electricity use data: Electricity meter installed pre-retrofit in each dwelling. Live data (per second) will be available in the dwellings that are part of the DSR action, through the platform. Dwelling heat demand data: Thermal comfort sensor (temperature, Relative humidity, occupancy etc.) installed pre-retrofit per dwelling. Live data (per second) will be available in all dwellings of the estate, through the platform. Survey capturing information on electricity & gas bills/ electricity & gas meters and energy related attitudes. Also capturing level of comfort.

Covariate control data

- Local weather station data including data on external climatic conditions in terms of temperature, relative humidity, solar radiation, etc. (per minute)
- Implementation masterplan per block and dwelling indicating start and end dates of each action.
- Building & apartment area, outdoor & indoor wall surface areas, orientation, window area
- Energy tariffs
- Grid carbon factor
- Specifications of old and new dwelling boilers.
- Residents social demographics (e.g. household type, household income, education, occupation)

6.2.3 Partners and responsibilities (per data source) (chart showing how WP8 will access the data)

The **Royal Borough of Greenwich (RBG)** is the public authority building owner of the public residential building. RBG coordinates the overall activities of the project and is the responsible for the design of the deep retrofit intervention on public buildings. RBG is responsible for the procurement process and has identified the contractor who will install the equipment under its supervision. Finally, RBG is responsible for making data available (in line with GDPR) either through data being stored in the London City data Store, or through another medium such as direct communication.

Sharing Cities WP8 (SC8) contributed to the design activities and to the definition of the pre- and post-retrofit energy and comfort monitoring plan for public buildings. Moreover, it participates in monitoring and analysis of data received during the pre- and post-intervention, it analyses all the data that other partners collect and make available through the Sharing Cities project databases.

Kiwi Power is responsible for installing the dwelling electricity meters (and in some cases plug meters) and temperature and humidity sensors.

Greater London Authority responsible for storing the data as part of the London Datastore, and granting access to demonstrator partners.

Table 6.9: Flamsteed estate retrofit data timeline

Data Source	Month																										
	Before	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	After
Electricity - Solar																											-
Electricity - Communal																											-
Thermal imaging																											-
Thermal sensor - Dwelling																											-
Thermal survey - dwelling																											-
Gas use – Dwelling																											-
Electricity use- Dwelling																											-
Covariate data																											-

Table 6.10: Roles and responsibilities of partners for Flamsteed estate demonstrator evaluation

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect other data	Communicate data	Store data	Handle data privacy	
Electricity - Solar	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Electricity - Communal	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Thermal imaging	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Thermal sensor - Dwelling	SC8	RBG	Kiwi	SC8	RBG	GLA	RBG	-
Thermal survey - dwelling	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Gas use – Dwelling	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Electricity use- Dwelling	SC8	RBG	RBG	SC8	RBG	GLA	RBG	-
Covariate data	SC8	RBG	RBG	SC8	Kiwi	GLA	RBG	-

7 GREENWICH MOBILITY AND LAMPPOST

The Royal Borough of Greenwich mobility demonstrators aim to investigate the potential impact of shared and electric mobility solutions and evaluate their impact in the borough. The scheme focuses on residents within the demonstrator area which is RBG's Low Emission Neighbourhood (LEN) illustrated in Figure 7.1.

Figure 7.1: London Royal Borough of Greenwich (RBG) Low Emissions Neighbourhood (LEN)

7.1 eBike Sharing

The RBG e-bike demonstrator is a small-scale trial, that aims to investigate the potential impact and evaluate the benefits of e-bikes in the borough. Unlike larger schemes, this demonstrator does not include docking stations or point to point service. Instead it enables local residents to rent an e-bike, interact with it and utilise it over a period of four weeks as it best suits them. The demonstrator enables the sharing of a fleet of e-bikes among the local residents encouraging a transition to sustainable transport. The main features of the scheme are:

- It is accessible to residents and businesses in and around the LEN demonstrator area.
- e-bikes are loaned for a period of 4 weeks to participants
- exchanges take place at monthly sessions (that tie in with the rental period) within the LEN that include a basic training on the features and use of e-bikes.

The demonstrator has been structured into phases with Phase 1 involving 16 e-bikes and running from November 2016 to February 2018, with more than 100 residents participating. For Phase 2, an additional 16 bikes will be included in monthly circulation and the scheme will be available borough-wide.

7.1.1 Implementation stages & timeline

The e- bike mobility demonstrator of RBG consists of Phases described below:

- Phase 0: (up to October 2016): Pre-Phase 1 Pilot
- Phase 1: (November 2016-June 2018): 16 bike Pilot
- Intermediate Phase: (March 2018 – December 2018): Training program

- Phase 2: (January 2019 onwards): 32 bike scheme

It is also meaningful to establish temporal implementation stages for with respect to data collected for each participating user:

- Stage 0: Pre-e-bike rental (baseline)
- Stage 1: During e-bike rental
- Stage 2: Post-e-bike rental

7.1.2 Data source specifications and timeline

The evaluation requires to associate the use of the e-bikes to car trips replaced and also:

- CO2 emissions
- Travel costs
- Travel times
- User experience

To evaluate the performance within the LEN demonstrator area, before and after the demonstrator implementation, a set of data sources have been identified that are listed in Table 7.1. The following data specifications require to be met for the RBG e-bike demonstrator:

Travel diary (web service): Trips data through the travel diary require to be collected for each user for at least a week prior to renting the e-bike and the third week of the trial. The hand and paper diary requires to be completed just before and during the trial, as the user has a better memory of the trips undertaken. Alternatively, the user can be tracked automatically through a smartphone. GPS data: The GPS device requires to continuously provide the coordinates location of the e-bike with distance accuracy of up to 5 meters and data frequency of up to 1 minute intervals. Baseline and follow-up user survey(s): The requires to complete the baseline survey (see Appendix) before starting the e-bike trial and to complete the follow-up survey (see Appendix) immediately after completing the e-bike trial.

Monitored data/ data inquiries: Information on parking costs, policies, bike lanes km, new bike sharing schemes, events taking place in LEN. Data on the scheme features and other related policies are collected to provide sufficient covariate control for the statistical analysis. Scheme operator interview: An interview on the local authority experience gained through the scheme is undertaken before and after the completion of the scheme. How e-bike sharing procurement documents are anticipated to be amended in the future based on scheme knowledge is considered.

Covariate data: Weather & Travel incidents data (borough): Data collected for covariate control.

7.1.3 Partners and responsibilities

The Royal Borough of Greenwich (RBG) is the funder and overarching project manager. RBG is responsible for procurement of the demonstrator considering the data specifications while also dealing with GPS data collection. The London Cycling Campaign (LCC) is the user facing delivery partner for Phase 1. Charlton Athletic Community Trust (CACT) is the user facing delivery partner for Phase 2. The delivery partner is responsible for handing the bikes to the users and running the scheme, while collecting the required data through surveys at the start and end of the trial period. Sharing Cities WP8 (SC8) is responsible for the monitoring and evaluation of anonymous travel data received during both trial phases. London's Greater London Authority is responsible for collecting and storing the data.

The data are being collected by the delivery partner that is responsible to ensure that all the data collected during the rental period are complete. The delivery partner is responsible to supply all data collected to RBG and SC8 ensuring that the data are anonymous. Table 7.2 summarizes the handling process of all the data sources for e-bike mobility from the procurement process to the analysis, highlighting in the last column on the right, the risk associated to the evaluation if data source is not materialized.

Table 7.1: RBG e-bike demonstrator data timeline

Data Source	Month																															
	Before	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Travel diary																																
GPS data																																
Baseline user survey																																
Follow-up user survey																																
Monitored data																																
Interview owner/operator																																
Safety data (Borough)																																
Weather station																																

Table 7.2: Partner role in data collection process

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect other data	Communicate data	Store data	Handle data privacy	
Travel diary (web service)	All	N/A	N/A	LCC/CACT	LCC/CACT	LGA	RBG	-
GPS data	RBG	RBG	LCC/CACT	N/A	LCC/CACT	LGA	RBG	-
Bike user survey	All	N/A	N/A	LCC/CACT	LCC/CACT	N/A	RBG	-
Monitored data/ data inquiries (costs, policies, bike lanes km, new bike sharing schemes)	All/ Imperial	N/A	N/A	Imperial	N/A	N/A	RBG	-
Interview owner/operator Congestion model	RBG/ Imperial	N/A	N/A	Imperial	N/A	N/A	RBG	-
Weather station	RBG	N/A	N/A	Imperial	N/A	N/A	RBG	-

7.2 eCargo Bike

The Royal Borough of Greenwich (RBG) developed the Zero Emission Delivery (ZED) cargo bike trial to explore the potential to reduce deliveries carbon footprint by undertaking a transition from vans to e-Cargo bikes. The scheme focuses on local organizations and businesses within the demonstrator area which is RBG's Low Emission Neighbourhood (LEN) illustrated in Figure 7.1. The scheme aims to assess the associated costs and benefits, with a view to scale-up and help as many local organizations/ businesses as possible to make a transition from vans to e-Cargo bikes.

The demonstrator has been structured into phases with Phase 1 involving a single business pilot for a period of 6 months starting in April 2018. Based on the evaluation of Phase 1, a Phase 2 with five additional businesses involved is anticipated. The business selected for phase 1, undertakes deliveries from a retail store located in the LEN to the SouthEast and Central London. The business delivers food items including meat, fish, cheese and fruit and vegetable by van to local residents and businesses. Their existing delivery volumes range from six to ten deliveries every day; their free local deliveries are to adjoining postcodes but they do deliver to as far as Plumstead and into central London.

7.2.1 Implementation stages & timeline

The e-Cargo bike mobility demonstrator of RBG consists of Phases described below:

- Phase 0: (up to March 2018): Pre-Phase 1 Pilot
- Phase 1: (April 2018-September 2018): Phase 1 Pilot
- Phase 2: (October 2018 – December 2020): Phase 2

It is also meaningful to establish temporal implementation stages for with respect to data collected for each participating business:

- Stage 0: Van deliveries (baseline)
- Stage 1: Van and e-Cargo bike deliveries (up to 6 months)
- Stage 2: Post-trial

7.2.2 Data source specifications and timeline

The evaluation requires to associate the use of the e-Cargo bike to actual trips replaced and also:

- CO2 emissions
- Delivery costs
- Delivery times
- User experience

To evaluate the performance within the demonstrator area (LEN) of the specific site before and after the demonstrator implementation, a set of data sources have been identified that are listed in Table 7.3. The following data specifications require to be met as a minimum for the RBG e-Cargo bike demonstrator:

Travel diary/ Delivery log: Trips data through the travel diary/ delivery log require to be collected for each delivery of each business for at least one month prior to starting the use of the e-Cargo bike. Also, throughout the period that both a van and the e-Cargo bike are available and also for a week post the 6-month adaptation period. An alternative to the hand and paper diary/ delivery log, deliveries can be tracked automatically through a smartphone. The delivery log records the time, date and destination of individual deliveries. This allows the isolation of individual journeys. GPS data: The GPS device requires to continuously provide the coordinates location of the e-Cargo bike with distance

accuracy of up to 5 meters and data frequency of up to 5-minute intervals enabling to identify when the vehicle is in motion or not. A GPS unit requires to be installed on other modes of delivery (e.g. van) to monitor its movements and timings.

Baseline and follow up user survey: Interview with a business representative directly associated to the use of the e-Cargo bike is required prior (up to a week before), during (week after two thirds of rental completed) and after (up to a week after) the rental period of the e-Cargo bike. Monitored data/ data inquiries: Information on parking costs, policies, bike lanes km, new bike sharing schemes, events taking place in LEN. Data on the scheme features and other related policies are collected to provide sufficient covariate control for the statistical analysis. Scheme operator interview: An interview on the local authority experience gained through the scheme is undertaken before and after the completion of the scheme. How e-Cargo bike sharing procurement documents are anticipated to be amended in the future based on scheme knowledge is considered. Weather data: Data collected for covariate control and RBGs mobility safety data.

7.2.1 Partners, responsibilities and collection process

The Royal Borough of Greenwich (RBG) is the overarching project manager of the e-bike scheme. RBG is responsible for procurement of the demonstrator considering the data specifications. Sustrans is the user facing delivery partner. It is responsible for running the scheme, while collecting the required data. Sharing Cities WP8 (SC8) is responsible for the monitoring and evaluation of anonymous travel data received during the Phase 1 trial.

Table 7.3: RBG e-logistics demonstrator data timeline

Data Source	Month																									
	Before	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	After
Travel diary/ Delivery log																											
GPS e-Cargo bike data																											
GPS other mode data																											
Baseline and follow-up user survey																											
Safety data (Borough)																											
Monitored data/ data inquiries (costs, policies, bike lanes km, new bike sharing schemes)																											
Interview scheme operator																											
Weather station																											

Table 7.4: Partner role in data collection process

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
Travel diary/ Delivery log	All	N/A	N/A	Sustrans	N/A	GLA	N/A	-
GPS e-Cargo bike data	All	RBG	Sustrans	Sustrans	N/A	GLA	N/A	-
GPS other mode data	All	RBG	Sustrans	Sustrans	N/A	GLA	N/A	-
Baseline and follow-up user survey	All	N/A	N/A	Sustrans	N/A	GLA	N/A	-
Monitored data/ data inquiries	Imperial/ RBG	N/A	N/A	Imperial	N/A	N/A	N/A	-
Interview scheme operator	Imperial/ RBG	N/A	N/A	Imperial	N/A	N/A	N/A	-

7.3 eV Mobility, Charging and Smart Parking

The RBG Mobility demonstrator involves the installation of various types of eV Charging Points and Smart Parking Sensors around the Low Emission Neighbourhood. Some of the eV Charging Points operate as a function of Smart Lampposts. It also involves the introduction of fully electric car club vehicles. The fully electric vehicles (eVs) are parked on street in dedicated EV car club bays, with each bay furnished with a charging point and a parking sensor.

The aim of the fully electric car club vehicles scheme is to improve air quality through trip reduction and through providing a zero-emission alternative to conventional car club vehicles. An additional aim is to introduce the idea and experience of driving electric vehicles to residents/businesses through a car club format, to encourage the private purchase/uptake of EVs amongst those groups.

7.3.1 Implementation stages & timeline

The RBG eV Mobility demonstrator consists of two implementation stages:
Stage 0: Baseline
Stage 1: Post-implementation of eV Car Club, Smart Parking Sensors, and eV Charging Points. Stage 1 is anticipated to start in January 2019. Demonstrator hardware like the eV bays, charge points and smart parking sensors are anticipated to be introduced gradually over a period of 2 months.

7.3.1 Data source specifications and timeline

To evaluate the performance of the mobility demonstrator before and after implementation, as set of data sources have been identified that are listed in Table 7.5.

The eV Car Club evaluation is based on the number of Car Club memberships and the usage of each vehicle in terms of distance travelled. Data from the eV charge points will provide dynamic status of the charge point indicating whether it is in use, free or booked. Complementary to the dynamic data, historical data will be available indicating usage per site, and including customer numbers. The location of the charge points will be recorded as the address and a number associated to each point. The Smart Parking data will provide dynamic status of the parking bay in terms of occupation, i.e. a snapshot of whether a bay is in use. Contextual data on the location of the Smart Parking Sensors will be provided using street and unique ID numbers.
Additional contextual data will be monitored to capture parameters influencing mobility in the LEN area. Interviews with scheme stakeholders will be undertaken.

7.3.1 Partners, responsibilities and collection process

The Royal Borough of Greenwich (RBG) is the funder and overarching project manager. RBG is responsible for procurement of the demonstrator considering the data specifications. Enterprise is the eV Car Club operator responsible for running the scheme and sharing usage data. Bluepoint is the eV Charge Point operator responsible for running the scheme and sharing usage data. Smart Parking is the Smart Parking sensor scheme operator and is responsible for sharing sensor occupancy data.

GLA and the London City Data Store as part of the Sharing Cities programme, will be developed to ingest real time data via API, will act as an aggregator and store for this data, able to build cumulative time series data, and share data via API with organisations granted access.
Imperial College London as the monitoring and evaluation partner of the Sharing Cities programme is responsible for the creation of Local Monitoring Plans for each of the schemes, ensuring robust monitoring and evaluation of the impact of schemes.

Table 7.5: RBG eV Mobility and Smart Parking demonstrator data timeline

Data Source	Month																														
	Before	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
eV Car Club aggregated																															
Smart parking sensor occupancy																															
eV Charge point live use																															
eV Charge point historical																															
Monitored data/ data inquiries (costs, policies, bike lanes km, new bike sharing schemes)																															
Interview owner/operator																															

Table 7.6: Partner role in data collection process

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect other data	Communicate data	Store data	Handle data privacy	
eV Car Club aggregated	SC8	RBG	Enterprise	-	Enterprise	GLA	-	-
Smart parking sensor occupancy	SC8	RBG	Smart Parking	-	Smart Parking	GLA	-	-
eV Charge point live use	SC8	RBG	Bluepoint	-	Bluepoint	GLA	-	-
eV Charge point historical	SC8	RBG	Bluepoint	-	Bluepoint	GLA	-	-
Monitored data/ data inquiries (costs, policies, bike lanes km, new bike sharing schemes)	SC8	RBG	SC8	-	SC8	-	-	-
Interview owner/operator	SC8	RBG	SC8	-	SC8	-	-	-

8 MILAN BUILDING RETROFIT AND SEMS

Building retrofit in Milan is based on many actions focused on the substantial reduction of public and private residential buildings' energy needs, providing, at the same time, adequate thermal comfort conditions for occupants. The improvement of the buildings' transparent and opaque envelope and the replacement of the service systems with new and more efficient ones, are therefore core actions of this demonstrator.

8.1 Public and Private Buildings

Both public and private multi property buildings are involved in the retrofit process; the selected public residential building has been chosen by the Municipality in the Southern-East area of Milan (Via S. Bernardo 29A) instead, the selection of the multi property residential buildings was made through public calls. The owners of the multi property buildings have proposed their own buildings for the retrofit process and have been engaged in the retrofit project through a co-design process. Also the occupants of the public building have been involved in the awareness process to make them conscious of the benefits derived from the building retrofit.

A graphical summary of the implemented actions in the public residential building of Via San Bernardo is reported in Figure 8.1, and the actions implemented is six private residential building are shown in Table 8.1.

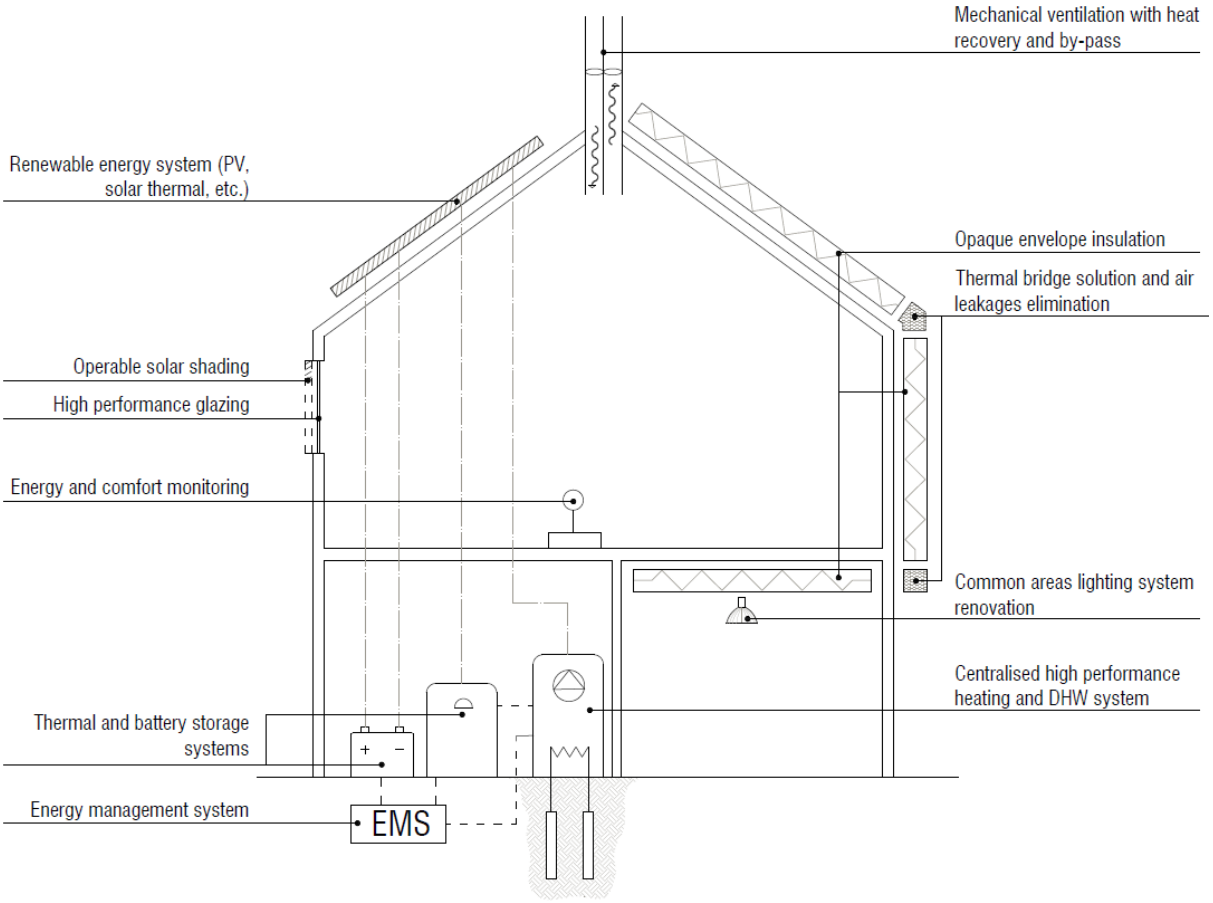


Figure 8.1: Graphical summary of retrofit actions implemented in the public residential building in Milan

Table 8.1: Retrofit actions implemented in the private buildings in Milan

Retrofit actions / Building	External walls thermal insulation	Internal wall insulation	Void insulation in external wall	Roof thermal insulation	Attic insulation	Basement thermal insulation	Entrance hall insulation	Thermostatic valves installation	High efficiency system generation installation	System remote management	LED in communal areas	PV panels installation
Via Benaco			x	x		x	x	x	Condensing boiler	x	x	x
Via Tito Livio	x					x					x	x
Via Passeroni				x		x			Condensing boiler	x		x
Via Verro	x			x				x		x	x	x
Via Fiamma	x					x	x					
Via Caviglia 3/a (Teicos headquarters)		x		x	x	x			Air Heat pump		x	x

To properly assess the impacts of the retrofit actions on the building performance, an energy and comfort monitoring plan has been designed; however, the monitoring activities are under development due to the on-going data implementation process on the project's data platform.

8.1.1 Implementation stages & timeline

The building demonstrator in Milan, and in particular the data collection activities, focused on quantitative assessment of building performance, consist of two major stages, baseline (Stage 0) and post-retrofit (Stage 1), to obtain a comparison analysis of before and after retrofit in terms of energy use and thermal comfort conditions. Therefore, baseline stage (stage 0) collects pre-retrofit data, while stage 1 collect data after the retrofit activities. Both stages include data related to energy, thermal comfort and indoor air quality, weather and energy simulation as reported below and in Table 8.2.

Stage 0: Baseline

- A) energy data
- B) thermal comfort and indoor air quality data
- C) weather data
- D) simulation data

Stage 1: Post-retrofit

- A) energy data
- B) thermal comfort data
- C) weather data
- D) simulation data

For the building demonstrator, the stages are identified in Table 8.2. For each stage, the monitored data group are the same and are related to energy, thermal comfort and indoor air quality, weather and energy simulation. Energy data include thermal, electrical energy and gas use data from meters or bills, thermal comfort and indoor air quality data include data from comfort survey and from sensors installed inside the apartments, weather data include data from the weather station installed in Milan in April 2017 and simulation data include data from energy simulation if foreseen.

Table 8.2: Building demonstrator stages and unique data groups

Stage	Timeline	Unique Data Group
0	January 2016 – June 2019 (estimate)	A: energy data
		B: thermal comfort and indoor air quality data
		C: weather data
		D: simulation data
1	June 2019 (estimate) – December 2020	A: energy data
		B: thermal comfort and indoor air quality data
		C: weather data
		D: simulation data

Energy data include thermal energy, electrical energy and gas use data from meters or bills, thermal comfort and indoor air quality data include data from comfort survey and from sensors installed inside the apartments, weather data include data from the weather station installed in Milan in April 2017 and simulation data include data from energy simulation if foreseen.

8.1.2 Data source specifications and timeline

Public residential buildings

To evaluate the performance of the Milan residential building before and after the demonstrator implementation, a set of data sources have been identified and listed in Table 8.3. The "data description" column provides specifications on which data (e.g. thermal energy, electrical energy, air temperature data, relative humidity (RH) data, etc.) will be recorded and monitored per each data group (e.g. energy data, thermal comfort and indoor air quality data (IAQ), weather data and simulation data) and in how many apartments these data are recorded. The list below reports information on how the different data is monitored:.

- Energy data are recorded by means of energy meters installed at building or at apartment level. However, data related to apartments will be deployed anonymously due to privacy issues.
- Thermal comfort and indoor air quality data are recorded by means of sensors installed in the apartments of the building. The SC8 multiparameter sensor, installed in 18 apartments of the public residential building, allows a more detailed thermal comfort study compared to the T-RH-CO_2 sensor installed in all the apartments of the building (66).
- Weather data include data on the external climatic conditions in terms of temperature, relative humidity, solar radiation, wind speed, wind direction, etc. and are monitored through the weather station installed in the Southern-East area of Milan (Via Feltrinelli 16).
- Simulation data are provided by the energy simulations carried out.

The end of the retrofit works for the public residential building is foreseen to be by June 2019, but it could be delayed; therefore, the post-retrofit monitoring phase may start from the end of the works.

Table 8.3: Public residential building monitoring data timeline. N.B. timeline is dependent on privacy issue and on construction site timeline. Also the beginning of the Stage 1 (post-retrofit phase) is dependent on the construction site works timeline.

Public residential building - Via San Bernardo 29A				**2018**									**2019**												**2020**											
				Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stage	Data Group	Data source	Data description	...	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Stage 0 - Baseline	A: Energy data	Energy meter	electrical energy (building level)																																	
			electrical energy (66 apartments)	Privacy issue - anonymous data																																
			thermal energy for heating (building level)																																	
	B: thermal comfort and IAQ data	SC8 - multiparameter sensors	Tair, Tglobe, RH, air speed, CO_2, Illuminance (18 apartments)	Privacy issue – anonymous data																																
		T-RH-CO_2 multiparameter sensors	Tair, RH, CO_2 (66 apartments)	Privacy issue – Anonymous data													Construction site works depending																			
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																																
	C: weather data	Weather station	Outdoor weather conditions																																	
	D: simulation data	energy simulation	Not foreseen but carried out																																	
Stage 1 - Post-retrofit	A: energy data	Energy meter	electrical energy (building level)																																	
			electrical energy (66 apartments)																Privacy issue – anonymous data																		
			thermal energy for heating (building level)																																	
			thermal energy for DHW (building level)																																	
			thermal energy for heating (66 apartments)																			Privacy issue – anonymous data														
			thermal energy for DHW (66 apartments)																Privacy issue – anonymous data																		
			PV produced and stored energy																																	
			Solar thermal produced energy																																	
		Gas meter	Gas use (66 apartments)																																	
	B: thermal comfort and IAQ data	SC8 - multiparameter sensors	Tair, Tglobe, RH, air speed, CO_2, Illuminance (18 apartments)																Privacy issue – anonymous data																		
		T-RH-CO_2 multiparameter sensors	Tair, RH, CO_2 (66 apartments)																Privacy issue – anonymous data																		
		questionnaire survey	Comfort survey																Privacy issue - PIA depending																		
	C: weather data	Weather station	Outdoor weather conditions																																	
	D: simulation data	energy simulation	Not foreseen but carried out																																	

8.1.3 Private residential buildings

Private buildings timelines for five private residential buildings (Via Benaco, Via Tito Livio, Via Passeroni, Via Verro, Via Fiamma) are reported in Table 8.4, Table 8.5, Table 8.6, Table 8.7 and Table 8.8. In addition, the monitoring timeline of the headquarters of TEICOS (Via Caviglia 3/a) is reported in Table 8.9. The data sources are the same as those identified for private residential buildings.

Some of the listed buildings have already been retrofitted, therefore, in order to have pre-retrofit data, energy data of the pre-retrofit phase have been requested to A2A and energy simulations (of the pre-retrofit and post-retrofit scenario) have been carried out by TEICOS using the EDILCLIMA software. However, also in this case, monitoring data of the apartments will be deployed anonymously due to the privacy issue.

Table 8.4: Via Benaco building data timeline. N.B. timeline is dependent on privacy issue and on construction site timeline

Private residential building - Via Benaco				**2018**									**2019**												**2020**											
				Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stage	Data Group	Data source	Data description	…	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Stage 0 - Baseline	A: Energy data	Energy meter	electrical energy (apartment level - reference apartments)																																	
		Energy meter	electrical energy (building level)																																	
		Gas meter	gas use (building level)																																	
		heat costs allocators	gas use (apartment level - reference apartments)																																	
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																	
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																																
	C: weather data	Weather station	Outdoor weather conditions																																	
	D: simulation data	energy simulation	Not foreseen but carried out	EDILCLIMA Simulation carried out																																
Stage 1 - Post-retrofit	A: energy data	Energy meter	electrical energy (apartment level - reference apartments)																																	
		Energy meter	electrical energy (building level)																																	
		Gas meter	gas use (building level)																																	
		heat costs allocators	gas use (apartment level - reference apartments)																																	
		Datalogger	PV produced energy																																	
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																	
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																																
	C: weather data	Weather station	Outdoor weather conditions																																	
	D: simulation data	energy simulation	Not foreseen but carried out	EDILCLIMA Simulation carried out																																

Table 8.5: Via Tito Livio building data timeline. N.B. timeline is dependent on privacy issue and on construction site timeline

Private residential building - Via Tito Livio				**2018**									**2019**												**2020**											
				Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stage	Data Group	Data source	Data description	…	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Stage 0 - Baseline	A: Energy data	Energy meter	electrical energy (apartment level - reference apartments)	(x)																															
		Energy meter	electrical energy (building level)	(x)																															
		Gas meter	gas use (building level)	(x)																															
		heat costs allocators	gas use (apartment level - reference apartments)	(x)																															
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions	(x)																															
	D: simulation data	energy simulation	Not foreseen but carried out	(x)	EDILCLIMA Simulation carried out																														
Stage 1 - Post-retrofit	A: energy data	Energy meter	electrical energy (apartment level - reference apartments)																																
		Energy meter	electrical energy (building level)																																
		Gas meter	gas use (building level)																																
		heat costs allocators	gas use (apartment level - reference apartments)																																
		Datalogger	PV produced energy																																
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions	(x)																															
	D: simulation data	energy simulation	Not foreseen but carried out	EDILCLIMA Simulation carried out																															

Table 8.6: Via Passeroni building data timeline. N.B. timeline is dependent on privacy issue and on construction site timeline

Private residential building - Via Passeroni				**2018**									**2019**												**2020**											
				Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stage	Data Group	Data source	Data description	…	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Stage 0 - Baseline	A: Energy data	Energy meter	electrical energy (apartment level - reference apartments)																																
		Energy meter	electrical energy (building level)																																
		Gas meter	gas use (building level)																																
		heat costs allocators	gas use (apartment level - reference apartments)																																
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions																																
	D: simulation data	energy simulation	Not foreseen but carried out	EDILCLIMA Simulation carried out																															
Stage 1 - Post-retrofit	A: energy data	Energy meter	electrical energy (apartment level - reference apartments)																																
		Energy meter	electrical energy (building level)																																
		Gas meter	gas use (building level)																																
		heat costs allocators	gas use (apartment level)																																
		Datalogger	PV produced energy																																
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions																																
	D: simulation data	energy simulation	Not foreseen but carried out	EDILCLIMA Simulation carried out																															

Table 8.7: Via Verro building data timeline. N.B. timeline is dependent on privacy issue and on construction site timeline

Private residential building - Via Verro				**2018**									**2019**												**2020**											
				Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stage	Data Group	Data source	Data description	…	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Stage 0 - Baseline	A: Energy data	Energy meter	electrical energy (apartment level - reference apartments)	(x)																															
		Energy meter	electrical energy (building level)	(x)																															
		Gas meter	gas use (building level)	(x)																															
		heat costs allocators	gas use (apartment level - reference apartments)	(x)																															
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions																																
	D: simulation data	energy simulation	Not foreseen but carried out	(x)	EDILCLIMA Simulation carried out																														
Stage 1 - Post-retrofit	A: energy data	Energy meter	electrical energy (apartment level - reference apartments)																																
		Energy meter	electrical energy (building level)																																
		Gas meter	gas use (building level)																																
		heat costs allocators	gas use (apartment level - reference apartments)																																
		Datalogger	PV produced energy																																
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions																																
	D: simulation data	energy simulation	Not foreseen but carried out	EDILCLIMA Simulation carried out																															

Table 8.8: Via Fiamma building data timeline. N.B. timeline is dependent on privacy issue and on construction site timeline

Private residential building - Via Fiamma				**2018**									**2019**												**2020**											
				Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stage	Data Group	Data source	Data description	…	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Stage 0 - Baseline	A: Energy data	Energy meter	electrical energy (apartment level - reference apartments)	(x)																															
		Energy meter	electrical energy (building level)	(x)																															
		Gas meter	gas use (building level)	(x)																															
		heat costs allocators	gas use (apartment level - reference apartments)	(x)																															
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions	(x)																															
	D: simulation data	energy simulation	Not foreseen but carried out	(x)	EDILCLIMA Simulation carried out																														
Stage 1 - Post-retrofit	A: energy data	Energy meter	electrical energy (apartment level - reference apartments)																																
		Energy meter	electrical energy (building level)																																
		Gas meter	gas use (building level)																																
		heat costs allocators	gas use (apartment level - reference apartments)																																
		Datalogger	PV produced energy																																
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions																																
	D: simulation data	energy simulation	Not foreseen but carried out		EDILCLIMA Simulation carried out																														

Table 8.9: Via Caviglia 3/a building data timeline. N.B. timeline is dependent on privacy issue and on construction site timeline

Private residential building - Via Caviglia 3/a				**2018**									**2019**												**2020**											
				Before	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stage	Data Group	Data source	Data description	...	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Stage 0 - Baseline	A: Energy data	Energy meters	electrical energy (building level)																																
		Gas meters	gas use (building level)																																
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey	Privacy issue - PIA depending																															
	C: weather data	Weather station	Outdoor weather conditions																																
	D: simulation data	energy simulation	Not foreseen but carried out	(x)	EDILCLIMA Simulation carried out																														
Stage 1 - Post-retrofit	A: energy data	Energy meters	electrical energy (building level)																																
		Datalogger	PV produced energy																																
	B: thermal comfort and IAQ data	Multiparameter sensors (MCF88)	Tair, RH, VOC, illuminance, air pressure (apartment level - reference apartments)																																
		questionnaire survey	Comfort survey																																
	C: weather data	Weather station	Outdoor weather conditions																																
	D: simulation data	energy simulation	Not foreseen but carried out	EDILCLIMA Simulation carried out																															

8.1.4 Partners and responsibilities

Public residential buildings

The **Energy Department of the Politecnico di Milano (PoliMi DENG)** contributed to the design activities and to the definition of the pre- and post-retrofit energy and comfort monitoring plan for public buildings. Moreover, Polimi DENG participates in monitoring and analysis of data received during the pre- and post-intervention, it analyses all the data that other partners collect and make available through the project databases (one belonging to Siemens and the other to CdM).

Municipality of Milan (CdM) is the public authority building owner of the public residential building. CdM coordinates the overall activities of the project for the City of Milan and is the responsible of the design of the deep retrofit intervention on the public building. The CdM created the specification that provide details on the equipment required for the monitoring plan of all the measurable data identified. CdM is also the responsible for the procurement process and has identified the contractor who will install the equipment under its supervision. Finally, DSIAD (IT Department of the Municipality if Milan), has developed the Interoperability Platform or Urban Sharing Platform (USP) to govern data between different departments of the Municipality, avoid data duplication, ensure secure data transition and facilitate external entities to access municipal data. Therefore, the interoperability platform (USP[1]) is the entity responsible for the data collection, data communication and data storage.

A2A/Unareti is the public energy utility providing electricity and gas data. Within the scope of activities for public buildings, A2A/Unareti has the task of collecting and providing the measurements gained through metering systems already installed for electricity and to be installed for gas (e.g. apartment energy use for cooking), to the other partners. Specifically, Unareti is responsible for collecting and providing two types of delivered energy data (electricity and gas) for apartments and for common areas.

Siemens is the technology provider and the Milan local leader for the SEMS analysis and implementation. Siemens provides the platform (SEMS-Monet) for collecting and analysing energy and environmental data. The data collected in this platform will be sent to the platform of the CdM making them available to the project partners (being implemented). The stored data will be analysed to provide the energy information of the building and apartments, and to manage the energy use of the common areas of the building. Siemens is then, responsible for the data communication, for the data storage and data privacy together with CdM and A2A/Unareti and for the data analysis together with PoliMi and CdM.

FUTURE ENERGY is the third party of TEICOS in the contest of the retrofit of private buildings. Together with PoliMi, has defined the characteristics and parameters to be measured with the environmental monitoring system “KIT INDOOR SC8” in 18 apartments. FUTURE ENERGY is the responsible for the installation of the environmental monitoring system “KIT INDOOR SC8” in the identified apartments.

Finally, **MM S.p.A** is the public building managing authority; however it is not partner of the Sharing Cities project. It is responsible for the management and maintenance of the monitoring equipment installed to monitor the energy delivered by the generation system during pre-retrofit intervention.

Table 8.10 summarizes the partners responsibility per data source for public buildings, highlighting in the last column on the right, the data risk for each data source. Since, within the project, more than one actor has the same kind of responsibility, in some cells of the following table there are more than one entry. For example, considering the energy meters, both Siemens and CdM are responsible for

[1] The Urban Sharing Platform (USP) of the Municipality of Milan is described within Chapter 10 – Paragraph 10.1.3.

the data storage since both will have their own platform in which the data will be stored and managed and A2A is the data provider.

As already mentioned in the previous deliverables, there is a pending request from CdM to the national privacy authority that will provide to the project partners a final decision on the possibility of monitoring energy and environmental data at the apartment level. Some monitoring activities may be delayed due to this issue. If the decision will be negative, only the aggregated or anonymous data of the apartments will be analysed.

Table 8.10: Public residential building partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
Energy meters	A2A/CdM	A2A/ CdM	A2A/ Contractor	USP/Monet	USP/Monet	USP/Monet	A2A	Privacy (apartment level)
Gas meters	A2A	A2A	A2A	USP/Monet	USP/Monet	USP/Monet	A2A	Privacy (apartment level)
SC8 - multiparameter sensors	Future Energy/PoliMi	Future Energy	Future Energy	USP/Monet	USP/Monet	USP/Monet	Future Energy	Privacy (apartment level)
T-RH-CO_2 multiparameter sensors	CdM	CdM	Contractor	USP/Monet	USP/Monet	USP/Monet	CdM/Siemens	Privacy (apartment level)
Questionnaire survey	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	Privacy (apartment level)
Weather station	Future Energy/PoliMi	Future Energy	Future Energy/Contractor	USP/Monet	USP/Monet	USP/Monet	-	-
energy simulation	-	-	-	-	-	-	-	-

Private residential buildings

TEICOS (and FUTURE ENERGY) is an engineering and construction SME with a large experience in public and private sector. They are the responsible for the energy retrofit of private residential multi owner buildings retrofit. It creates the specification that provide details on the equipment required for the monitoring plan of all the measurable indicators identified in D.8.2. Teicos is also the responsible for the procurement process and identifies the contractor who will install the equipment under its supervision.

A2A/Unareti is the public energy utility providing electricity and gas data. Within the scope of the activities for private buildings, A2A/Unareti has the task of collecting and providing the measurements gained through metering systems already installed, to the other partners. Specifically, Unareti is responsible for collecting and providing two types of data: electricity and gas data.

Municipality of Milan (CdM) is the public authority building owner of the public residential building. CdM coordinates the overall activities of the project for the City of Milan and is the responsible of the

design of the deep retrofit intervention on the public building. The CdM created the specification that provide details on the equipment required for the monitoring plan of all the measurable data identified. CdM is also the responsible for the procurement process and has identified the contractor who will install the equipment under its supervision. Finally, DSIAD (IT Department of the Municipality if Milan), has developed the Interoperability Platform or Urban Sharing Platform (USP) to govern data between different departments of the Municipality, avoid data duplication, ensure secure data transition and facilitate external entities to access municipal data. Therefore, the interoperability platform (USP[2]) is the entity responsible for the data collection, data communication and data storage.

Siemens is the technology provider and Milan local leader for the SEMS analysis and implementation. It provides the platform (SEMS-Monet) for collecting energy and environmental data. The data collected in this platform of the private residential building will be energy data (provided by A2A/Unareti) and environmental data from sensors installed in the apartments.

In case of private building, **PoliMi DEng** participate in the analysis activities of the available data. Table 8.11 summarizes the partners and responsibility per data source for private residential buildings highlighting in the last column on the right, the data risk for each data source. As for the public residential building, there is a pending request from CdM to the national privacy authority that will provide to the project partners a final decision on the possibility of monitoring energy and environmental data at the apartment level. Some monitoring activities may be delayed due to this issue. If the decision will be negative, only the aggregated or anonymous data of the apartments will be analysed.

Table 8.11: Private residential building partners and responsibility per data source

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
Energy meters	A2A	A2A	A2A	USP/ Monet	USP/Monet	USP/ Monet	A2A	Privacy (apartment level)
PV Datalogger	Future Energy	Teicos/ Future Energy	Future Energy	USP/ Monet	USP/Monet	USP/ Monet	Future Energy	-
Gas meters	A2A	A2A	A2A	USP/ Monet	USP/Monet	USP /Monet	A2A	Privacy (apartment level)
MCF88 - multiparameter sensors	Future Energy	Teicos/ Future Energy	Future Energy	USP/ Monet	USP/Monet	USP/ Monet	Future Energy	Privacy (apartment level)
Questionnaire survey	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	Privacy (apartment level)
Weather station	Future Energy/PoliMi	Future Energy	Future Energy/ Contractor	USP/ Monet	USP/Monet	USP/ Monet	-	-
Energy simulation	-	-	-	-	-	-	-	-

[2] The Urban Sharing Platform (USP) of the Municipality of Milan is described within Chapter 10 – Paragraph 10.1.3.

8.2 Milan SEMS

The Milan Sustainable Energy Management System (SEMS) is identified by the multiservice platform Monet provided by Siemens. Monet supports the monitoring, controlling and remote management of third-party field devices, installed in different areas and connected to internet, in order to offer advanced energy management services. The platform is also designed to store and, potentially manage, any other information that can be correlated to energy; for example, environmental data (temperature, relative humidity, illuminance) are acquired to correlate them with energy data.

In the context of Sharing Cities, the Monet platform collect environmental and energy data of public and private residential buildings and real time data from the weather station. The collection of these data is achieved through the following asset installation:

- Energy meters and environmental sensors;
- Gateways and SIM cards;
- Monet paltform.

In the case of the public residential building, where PV panels and an electrical energy storage system will be installed, the SEMS through advanced algorithms will optimize energy use and maximize energy self-consumption.

8.2.1 Implementation stages & timeline

The SEMS in Milan is strictly related to the building demonstrator and it consists of two major stages: baseline (Stage 0) and post-retrofit (Stage 1). As for the case of buildings, the baseline stage collects all the pre-retrofit data, but in this stage the SEMS performs just the function of the data monitoring and data collection, while during the phase of post-retrofit, when the platform will receive the data of the energy production and the data from the storage battery it will optimize the consumption through the implemented algorithms.

Stage 0: Baseline

A) energy data
B) thermal comfort and indoor air quality data
C) weather data

Stage 1: Post-retrofit

A) energy data
B) thermal comfort data
C) weather data

The implementation stages for the SEMS are identified in Table 8.12. Both the stages include data related to energy, thermal comfort and indoor air quality and weather conditions. Energy data include thermal and electrical energy data and gas consumption from meters, thermal comfort data include data from sensors installed inside the apartments of the buildings, weather data include data from the weather station installed in April 2017. In stage 1 energy data of the public residential building will be analysed in order to optimize energy usage and maximize the use of the energy produced on site.

Table 8.12: SEMS demonstrator stages and unique data groups

Stage	Timeline	Unique Data Group
0	January 2016 – June 2019 (estimate)	A: energy data
		B: thermal comfort and indoor air quality data
		C: weather data

1	June 2019 (estimate) – December 2020	A: energy data
		B: thermal comfort and indoor air quality data
		C: weather data

8.2.2 Data source specifications and timeline

To evaluate the performance of the specific site before and after the demonstrator implementation, a set of data sources have been identified. As previously defined, the data that the SEMS collects and monitors for the case of Milan are the same data coming from the building demonstrator, therefore the data sources and the timelines are the same described in the Milan private and public residential buildings (Section 8.1.2):

- Energy data will be recorded by means of energy meters installed at building or at apartment level. However, data related to apartments will be deployed anonymously due to privacy issues.
- Thermal comfort and indoor air quality data will be recorded by means of sensors installed in the apartments of the buildings.
- Weather data include data on the external climatic conditions in terms of temperature, relative humidity, solar radiation, etc. and are monitored through the weather station installed in the Southern-East area of Milan (Via Feltrinelli 16).

The monitoring timelines of the data monitored by the SEMS are described in Table 8.3 for the public residential building of Via San Bernardo 29/a and in Table 8.4, Table 8.5, Table 8.6, Table 8.7, Table 8.8 and in Table 8.9 for the private multi-property buildings.

8.2.3 Partners and responsibilities

The technology provider and the local leader for the SEMS in Milan is **Siemens**. Siemens provides the platform Monet for collecting and analysing data. Energy and environmental data are therefore collected by the Monet platform and the stored energy data of the public residential building will be analysed to manage and optimize the energy use of the building. Siemens is then, responsible for all the functions performed by the SEMS and for its procurement process as shown in Table 8.13.

Table 8.13: SEMS partners and responsibility

Demonstrator	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
SEMS - Monet	Siemens	Siemens	Siemens	Siemens	Siemens	Siemens	Siemens	Privacy

Considering the sources of the data implemented in the SEMS, these are the same highlighted for the public and private residential buildings and are reported in Table 8.14.

Milan interoperability platform (USP) and Siemens's platform (Monet) are the entity responsible for the data collection, data communication and data storage.

Table 8.14: Partner and responsibility per data analysed by the SEMS

Data source (defined in paragraph 8.1.2)	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
Energy meters	A2A	A2A	A2A	USP/Monet	USP/Monet	USP/Monet	A2A	Privacy (apartment level)
PV Datalogger (private res. buildings)	Future Energy	Teicos/ Future Energy	Future Energy	USP/Monet	USP/Monet	USP/Monet	Future Energy	-
Gas meters	A2A	A2A	A2A	USP/Monet	USP/Monet	USP/Monet	A2A	Privacy (apartment level)
SC8 - multiparameter sensors	Future Energy/PoliMi	Future Energy	Future Energy	USP/Monet	USP/Monet	USP/Monet	Future Energy	Privacy (apartment level)
T-RH-CO_2 multiparameter sensors	CdM	CdM	Contractor	USP/Monet	USP/Monet	USP/Monet	CdM/Siemens	Privacy (apartment level)
MCF88 - multiparameter sensors	Future Energy	Teicos/ Future Energy	Future Energy	USP/Monet	USP/Monet	USP/Monet	Future Energy	Privacy (apartment level)
Weather station	Future Energy/PoliMi	Future Energy	Future Energy/Contractor	USP/Monet	USP/Monet	USP/Monet	-	-

9 MILAN MOBILITY

9.1 eBike Sharing

The Sharing Cities project will provide 150 new e-bikes in sharing and 7 bike stations. These vehicles and infrastructures will reinforce the existing bike sharing service which started ten years ago. The Sharing Cities e-bikes and bike stations will be deployed in Porta Romana-Vettabbia project area and they will not generate an autonomous service but they will be part of the entire Milan bike sharing system, which works on a relevant part of the urban area. For this reason, it will be impossible and counterproductive to limit the use of the 150 Sharing Cities e-bikes only inside the Porta Romana-Vettabbia area, because the bicycles will move inside and outside the Sharing Cities district distribute themselves all around the city.

A GPS sensor on each of the 150 Sharing Cities e-bikes will give the opportunity to monitor the vehicles and control all their trips, in order to give to WP8 an adequate amount of data to evaluate the benefits of the action. Furthermore, the presence of the new 7 bike stations, with the others already deployed within the Sharing Cities Milan district, will improve the use of the vehicles which start their trips from this area and the number of vehicles which will arrive in the Porta Romana-Vettabbia district, supporting the reallocation of the e-bikes.

The data that will be monitored are resumed in Table 9.1.

Table 9.1: E-bike sharing data monitored

Data	Unit measure	Measure collection method
Daily time period with vehicle hire availability	% (min/min)	GPS on e-bike/ sensor on bike station
Vehicle use frequency	#/day	GPS on e-bike/ sensor on bike station
Ride distance per hire	km	GPS on e-bike/ sensor on bike station

GPS deployed on the e-bikes and sensors on the bike stations will monitor the vehicles daily use and availability, the increase of the number of trips generated every day, the distance ridden per hire and total.

As regard the evaluation of this action, it is made the hypothesis that only 20% of the trips are made in substitution of private car, while other trips substitute walk, public transport and private bicycle (Fishman et al, 2014)[3]. Starting from this information and considering ISPRA[4] Italian vehicles emission factors it will be possible to estimate the pollutant emissions and GHGs avoided with the e-bikes. Using the monitored information and the literature ones, the following indicators will be defined (Table 9.2).

Table 9.2: E-bike sharing indicators

Key Performance Indicator – KPI	Data	Unit measure
Vehicle availability	Daily time period with vehicle hire availability	% (min/min)
Vehicle use	Vehicle use frequency	#/day
Avoided Emission: PM10	Total ride distance; ISPRA Emission Factors	kg PM10
Avoided Emission: PM2.5	Total ride distance; ISPRA Emission Factors	kg PM2.5
Avoided Emission: NOx	Total ride distance; ISPRA Emission Factors	kg NOx
Avoided Emission: NMVOC	Total ride distance; ISPRA Emission Factors	kg NMVOC
Avoided GHG: CO_2	Total ride distance; ISPRA Emission Factors	kg CO_2

[3] Fishman, E., Washington, S., & Haworth, N. (2014). Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia. Transportation Research Part D: Transport and Environment, 31, 13-20.
[4] ISPRA – (Istituto Superiore per la Protezione e la Ricerca Ambientale) is an italian centre of research which provide, every year, a database with national vehicles emission factors. The database is realized basing on EMEP/EEA air pollutant emission inventory guidebook 2016 and IPCC 2006 GHGs Guidelines.

9.1.1 Implementation stages & timeline

The Milan e-bike sharing service consists of four implementation stages:

- Stage 0: Monitoring plan and privacy issue resolution.
- Stage 1: Resolution of bureaucratic issue and detailed design of the action.
- Stage 2: Assets implementation.
- Stage 3: Monitoring and evaluation of the benefits.

The previous stages are resumed in following Table 9.3.

Table 9.3: E-bike sharing implementation stages and timeline

Stage	Timeline	Unique Data Group
0	2016-2017	Definition of the data to monitor, definition of the KPIs, identification and resolution of privacy issue.
1	January 2018 – August 2018	Interaction between Milan Municipality and the e-bike manager: detailed action design process, purchasing of the vehicles and bike stations.
2	September 2018 – December 2018	Assets implementation (bike stations and e-bikes).
3	2019 - 2020	Monitoring and evaluation of the benefits.

9.1.2 Data source specifications and timeline

In order to evaluate the performance of Milan e-bike sharing action, a set of data sources has been identified. A GPS sensor will be deployed on all the 150 e-bikes, in this way it will be possible to measure the distance ride in every hire and the total distance travel by the entire system. Sensors on the 7 bike stations will give information about the starting and the finishing of every hire and will help to count the number of trips realized by every e-bike. Finally, to identify the emissions saved thanks the e-bikes system it is necessary to use literature information and an emission factors database.

As explained in the previous paragraph, it will be considered a private cars substitution rate of 20% as reported in Fishman et al (2014). To define the emission factors of the private cars which are supposed to be substituted by the e-bikes it will be used the information reported in the ISPRA database. The last available national emission factors of cars will be considered. In the following Table 9.4 the e-bike sharing data source specifications and timeline are resumed.

Table 9.4: E-bike sharing data source specifications and timeline

Data Source	Month																														
	Before	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
E-bikes GPS data																															
Bike stations sensors																															
ISPRA Emissions factor																															
Car substitution rate																															

9.1.3 Partners and responsibilities

RSE is responsible of monitoring and evaluation of e-bike sharing action, supporting its analysis with data collected by GPS and sensors. RSE identifies suitable database and literature information in order to provide useful data for the benefits evaluation.

ATM (Azienda Trasporti Milanesi SpA) is Municipality of Milan public society which manages Milan public transport. ATM will collect all e-bikes sharing information and then these data will be shared with RSE to analyze and evaluate e-bike sharing benefits.

In Table 9.5 the e-bike sharing partners and responsibilities per data source are resumed. Milan interoperability platform (USP) is the entity responsible for the data collection, data communication and data storage.

Table 9.5: E-bike sharing partners and responsibilities per data source

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
E-bikes GPS data	RSE	ATM	Clear Channel	USP	USP	USP	ATM/Clear Channel	-
Bike stations sensors	RSE	ATM	ATM	USP	USP	USP	ATM/Clear Channel	-
ISPRA Emissions factor	-	-	-	RSE (collect other data)	-	-	-	-
Car substitution rate	-	-	-	RSE (collect other data)	-	-	-	-

9.2 e-Vehicle Sharing Charging Points

This action will create suitable conditions to support the presence of electric vehicles (60 e-car sharing) in Milan Sharing Cities district. The goal of this asset is to have at least 60 available sharing electric vehicles in the project area. For this reason the focus of this action is on the mobility areas designed and provided by NHP partner: in these "mobility islands" there will be deployed 60 electric charging points (20 fast and 40 standard) which will support the e-car sharing grow in the project district. The charging points will be used to measure some parameters necessary for the monitoring of the project: during the recharging of the vehicles the charging points will measure vehicles battery level and, starting from this information, the distance travelled will be estimated.
The data that will be monitored are resumed in Table 9.6.

Table 9.6: E-car sharing charging points data monitored

Data	Unit measure	Measure collection method
Energy used per km	kWh/km	Information estimated consulting AMAT annual Milan car-sharing report (2016 year)
Vehicles distribution	#	Information estimated consulting AMAT periodic Milan car-sharing reports
Energy delivered in the period	kWh/d	Information obtain by the charging points which provide the supplied energy

The availability of 60 electric charging points within Milan Sharing Cities District will promote the grow of electric sharing vehicles in the area. The charging points will be used to measure the energy furnished to the e-cars, in order to estimate the distance driven by the vehicles. Thanks to the charging points the percentage of battery fullness, starting and finishing time of recharging will be monitored.
In order to calculate the distance driven by the e-cars it will be necessary to evaluate the efficiency of the vehicles, the energy used per driven km (kWh/km). It will not possible to obtain this information from the charging points or from other types of sensors. For this reason, this information will obtained consulting AMAT (Agenzia Mobilità Ambiente e Territorio) annual Milan car sharing report. In this official document an estimation of the efficiency of all Milan e-cars in sharing is reported, starting from information and data got directly from Milan e-car sharing operators.

As regard the evaluation of this action, it is made the hypothesis that every trip realized with the e-cars is realized in substitution of private cars. Starting from this information and considering ISPRA Italian vehicles emission factors it will be possible to estimate the pollutant emissions and GHGs avoided thanks the e-car sharing charging points. The possible grow of e-car sharing vehicles within the project area will be monitored using AMAT information about Milan e-car sharing service, reported in its periodic report. In this way it will be possible to understand if the deploy of the 60 charging points in the Sharing Cities District will help the grow of e-vehicles in the area. Using the monitored information and the literature ones, the following indicators will be defined (Table 9.7).

Table 9.7: E-car sharing charging points indicators

Key Performance Indicator – KPI	Data	Unit measure
Energy provided	Energy delivered by the charging points considering starting and finishing time of the recharge	kWh
E-car sharing distribution	Vehicles distribution as number of e-car sharing vehicles within the project area	#
Avoided Emission: PM10	Total ride distance; ISPRA Emission Factors	kg PM10
Avoided Emission: PM2.5	Total ride distance; ISPRA Emission Factors	kg PM2.5
Avoided Emission: NOx	Total ride distance; ISPRA Emission Factors	kg NOx
Avoided Emission: NMVOC	Total ride distance; ISPRA Emission Factors	kg NMVOC
Avoided GHG: CO_2	Total ride distance; ISPRA Emission Factors	kg CO_2

9.2.1 Implementation stages & timeline

The Milan e-car sharing charging points action consists of four implementation stages:

- Stage 0: Monitoring plan and privacy issue resolution.
- Stage 1: Resolution of bureaucratic issue and design of the action.
- Stage 2: Assets implementation.
- Stage 3: Monitoring and evaluation of the benefits.

The previous stages are resumed in following Table 9.8.

Table 9.8: E-car sharing charging points implementation stages and timeline

Stage	Timeline	Unique Data Group
0	2017	Definition of the data to monitor, definition of the KPIs, identification and resolution of privacy issue
1	January 2017 – November 2018	Interaction between Milan Municipality and the charging points manager: action design process, purchasing of the charging points
2	November 2018 – December 2018	Assets implementation (charging points in the mobility islands)
3	2019 - 2020	Monitoring and evaluation of the benefits

9.2.2 Data source specifications and timeline

In order to evaluate the performance of Milan e-car sharing charging points action, a set of data sources has been identified. The main source of information will be the charging points deployed within the mobility island in the project district. These devices will be able to collect information from the e-cars connected, allowing to estimate the distance driven by the vehicles (as explained in the previous paragraph). The e-cars distribution and presence in the project district and the e-vehicles efficiency (kWh/km) will be obtained consulting AMAT periodic and annual reports on Milan e-car sharing service. To define the emission factors of the private cars which are supposed to be substituted by the e-cars in sharing it will be used the information reported in the ISPRA database. The last available national emission factors of cars will be considered.

In the following Table 9.9 the e-car sharing data source specifications and timeline are resumed.

Table 9.9: E-car sharing charging points data source specifications and timeline

Data Source	Month																														
	Before	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Charing points																															
ISPRA Emissions factor																															
Milan e-car sharing distribution and use																															
Milan e-car sharing efficiency																															

9.2.3 Partners and responsibilities

RSE is responsible of the monitoring and evaluation of e-car sharing charging points, supporting its analysis with data collected by charging points deployed in the Sharing Cities district. RSE identifies suitable database and literature information in order to provide useful data for the benefits evaluation.

AMAT (Agenzia Mobilità Ambiente e Territorio) is Municipality of Milan public society which provide analysis and support about environment and local transport themes. AMAT collect Milan e-car sharing information in order to monitor and control this service. All the collected information are organized in periodic and annual reports. RSE will use these documents to analyse and evaluate the service benefits.

NHP is the technical partner which will install the charging points within Milan Sharing Cities district.
In Table 9.10 the e-car sharing charging points partners and responsibilities per data source are resumed. Milan interoperability platform (USP) is the entity responsible for the data collection, data communication and data storage.

Table 9.10: E-car sharing charging points partners and responsibilities per data source

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
Charging points	RSE	NHP	NHP	USP	USP	USP	NHP	-
ISPRA Emissions factor	-	-	-	RSE (collects other data)	-	-	-	-
Milan e-car sharing distribution and use	-	-	-	RSE/AMAT (collect other data)	-	-	-	-
Milan e-car sharing efficiency	-	-	-	RSE/AMAT (collect other data)	-	-	-	-

9.3 Smart Parking

Smart parking sensors will be used in the following areas:

- Disabled parking check (16 sensors).
- Public transport stop areas check (5+6 sensors deployed in two bus stops).
- Logistic area check (48 sensors).
- Sharing vehicles mobility areas check (100 sensors: 60 sensors in recharging points parking and 40 sensors in sharing vehicles parking).

A single sensor is able to detect the presence of a parked vehicle and identify stops longer than allowed. In the Sharing Cities project, the smart parking system will not be able to identify parking improper use, but it will be able only to verify presence or absence of a vehicle in the parking. For this reason, it's not easy to evaluate benefits generated by this action, but generally, parking longer than 20 minutes for logistic and longer than 5 minutes for public transport are consider as parking improper use. Starting from this information and using smart parking sensors information (presence/absence of a vehicle and stopping time) the logistic and public transport parking improper uses will be estimated. The data that will be monitored are resumed in Table 9.11.

Table 9.11: Smart parking data monitored

Data	Unit measure	Measure collection method
Park frequency use	#/day	Parking sensor
Improper park frequency use (logistic: more than 20 minutes; public transport: more than 5 minutes)	min	Parking sensor

Using the monitored information the following indicators will be defined (Table 9.12).

Table 9.12: Smart parking indicators

Key Performance Indicator – KPI	Data	Unit measure
Parking use (TPL)	Park frequency use	#/day
Parking use (logistics)	Park frequency use	#/day
Improper use TPL	Park frequency use, Improper park frequency use	% (min/min)
Improper use logistics	Park frequency use, Improper park frequency use	% (min/min)

9.3.1 Implementation stages & timeline

The Milan smart parking action consists of four implementation stages:

- Stage 0: Monitoring plan and privacy issue resolution.
- Stage 1: Resolution of bureaucratic issue and design of the action.
- Stage 2: Assets implementation.
- Stage 3: Monitoring and evaluation of the benefits.

The previous stages are resumed in following Table 9.13.

Table 9.13: Smart parking implementation stages and timeline

Stage	Timeline	Unique Data Group
0	2017	Definition of the data to monitor, definition of the KPIs, identification and resolution of privacy issue
1	November 2017 – October 2018	Interaction between Milan Municipality and the smart parking managers: action design process, purchasing of the charging points
2	November 2018 – December 2018	Assets implementation (smart parking sensors)
3	2019 - 2020	Monitoring and evaluation of the benefits

9.3.2 Data source specifications and timeline

In order to evaluate the performance of Milan smart parking action, a set of data sources has been identified.
The main source of information will be sensors deployed in the parking areas used to monitor the presence or absence of parked vehicles and parking period.
In the following Table 9.14 the smart parking data source specifications and timeline are resumed.

Table 9.14: Smart parking data source specifications and timeline

Data Source	Month																														
	Before	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Smart parking sensors																															

9.3.3 Partners and responsibilities

RSE is responsible of the monitoring and evaluation of smart parking, supporting its analysis with data collected by the parking sensors deployed in the Sharing Cities district.

Kiunsys and A2A are technical partners which will install the smart parking sensors within Milan Sharing Cities district.

In Table 9.15 the smart parking partners and responsibilities per data source are resumed. Milan interoperability platform (USP) is the entity responsible for the data collection, data communication and data storage.

Table 9.15: Smart parking partners and responsibilities per data source

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
Smart parking sensor	RSE	A2A	Kiunsys,	USP	USP	USP	-	-

9.4 Condominium e-Vehicle Sharing

At the end of 2017, AMAT has launched two public tenders to find buildings and operators that were interested to implement a condominium e-car sharing in the project district. The service will start in "Condominio Bacchiglione 21", a complex with 658 apartments and more of 100 people interested in the use of the service. This action provides two fully electric cars which will be used by the condominium inhabitants. Thanks the collaboration with the technical partner, which will provide the e-vehicles and the charging point, the following data will be monitored (Table 9.16).

Table 9.16: Condominium e-car sharing data monitored

Data	Unit measure	Measure collection method
Energy used per km	kWh/km	Sensor on electric vehicle
Battery level at hire starting	%	Sensor on electric vehicle
Battery level at hire stopping	%	Sensor on electric vehicle
Hire time	min	Sensor on electric vehicle
Drive distance per hire	km	Sensor on electric vehicle
Total distance driven	km/month	Sensor on electric vehicle
Energy delivered per hire	kWh/hire	Charging points

The sensors installed in the two e-cars will produce useful data and information which will be used to evaluate the performances of the service: distance driven, avoided emissions, avoided GHGs, energy consumed, hire time. The availability of the two e-cars in sharing will encourage the condominium inhabitants to avoid trips using their private cars. For this reason, it is made the hypothesis that every trip realized with the e-cars is realized in substitution of condominium people private cars. Starting from this information and considering ISPRA italian vehicles emission factors it will be possible to estimate the pollutant emissions and GHGs avoided thanks the e-car sharing charging points. Using the monitored information and the literature ones, the following indicators will be defined (Table 9.17).

Table 9.17: Condominium e-car sharing indicators

Key Performance Indicator – KPI	Data	Unit measure
Energy consumed	Energy consumed by the sharing vehicles	kWh
Avoided Emission: PM10	Total ride distance; ISPRA Emission Factors	kg PM10
Avoided Emission: PM2.5	Total ride distance; ISPRA Emission Factors	kg PM2.5
Avoided Emission: NOx	Total ride distance; ISPRA Emission Factors	kg NOx
Avoided Emission: NMVOC	Total ride distance; ISPRA Emission Factors	kg NMVOC
Avoided GHG: CO_2	Total ride distance; ISPRA Emission Factors	kg CO_2

9.4.1 Implementation stages & timeline

The Milan condominium e-car sharing consists of four implementation stages:

- Stage 0: Monitoring plan and privacy issue resolution.
- Stage 1: Resolution of bureaucratic issue and design of the action.
- Stage 2: Assets implementation.
- Stage 3: Monitoring and evaluation of the benefits.

The previous stages are resumed in following Table 9.18.

Table 9.18: Condominium e-car sharing implementation stages and timeline

Stage	Timeline	Unique Data Group
0	November 2017 – October 2018	Definition of the data to monitor, definition of the KPIs, identification and resolution of privacy issue
1	June 2018 – October 2018	Interaction between Milan Municipality and the condominium e-car sharing manager: action design process, purchasing of the vehicles

2	November 2018 – December 2018	Assets implementation
3	2019 - 2020	Monitoring and evaluation of the benefits

9.4.2 Data source specifications and timeline

In order to evaluate the performance of Milan condominium e-car sharing action, a set of data sources has been identified. The main source of information will be the sensors deployed on the two sharing e-cars. These devices will be able to collect information from the vehicles connected, allowing to monitor the main parameters of the sharing e-cars. The information related to the e-car energy consumptions will be collected with the charging points. To define the emission factors of the private cars which are supposed to be substituted by the e-car sharing it will be used the information reported in the ISPRA database. The last available national emission factors of cars will be considered. In the following Table 9.19 the condominium e-car sharing data source specifications and timeline are resumed.

Table 9.19: Condominium e-car sharing data source specifications and timeline

Data Source	Month																															
	Before	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Sensors on e-car sharing																																
Charging points																																
ISPRA Emissions factor																																

9.4.3 Partners and responsibilities

RSE is responsible of the monitoring and evaluation of the condominium e-car sharing, supporting its analysis with data collected by sensors deployed into the vehicles. RSE identifies suitable database and literature information in order to provide useful data for the benefits evaluation.

AMAT (Agenzia Mobilità Ambiente e Territorio) is Municipality of Milan public society which provide analysis and support about environment and local transport themes. AMAT collect Milan condominium e-car sharing information which are shared by the service operator. Then, these information are shared with RSE to analyse and evaluate the condominium e-car sharing benefits.

Milan Municipality (Comune di Milano – CdM) is the coordinator of the project overall activities and is responsible of condominium e-car sharing data communication and storage.

In Table 9.20 the condominium e-car sharing partners and responsibilities per data source are resumed. Milan interoperability platform (USP) is the entity responsible for the data collection, data communication and data storage.

Table 9.20: Condominium e-car sharing partners and responsibilities per data source

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
Sensors on e-car sharing	RSE	AMAT/operator	ReFeel	USP	USP	USP	ReFeel	-
ISPRA Emissions factor	-	-	-	RSE (Collects other data)	-	-	-	-

9.5 e-Logistics

The e-logistic demonstrator will involve the home delivery service provided by Carrefour. The demonstrator will cover all the dispatches to customers located in the Sharing Cities area that nowadays are carried out with ICE vehicles. Nine full electric vehicles (Nissan NV200) and two e-bicycles will replace the entire fleet operating in the project area. Ten Carrefour shops and markets, located nearby the Sharing Cities area, will make use of the e-logistic service. Moreover, nine charging station will be installed at the Carrefour shops, in order to optimize the charging operation.
The data that will be monitored are resumed in Table 9.21.

Table 9.21: E-logistic data monitored

Data	Unit measure	Measure collection method
Energy used per km	kWh/km	Sensor on electric vehicle
Battery level at starting and finishing working day	% or kWh	Sensor on electric vehicle
Daily deliveries	#/day	Delivery note
Drive distance	km	Sensor on electric vehicle

The GPS and the on-board units installed in the 9 e-vans and in the 2 e-cargo bikes will produce useful data and information which will be used to evaluate the performances of the service: distance driven, avoided emissions, avoided GHGs, energy consumed. The e-logistic vehicles will substitute ICE (Internal Combustion Engine) ones, which are now used by the logistic operator. For this reason, the. Hypothesis is made that every trip realized with the e-logistic vehicles is realized in substitution of combustion engine ones. The 9 e-vans will substitute 9 traditional diesel vans, the 2 e-cargo bikes, which have a lower capacity than traditional vehicles, will substitute a single diesel van. Starting from this information and considering ISPRA italian vehicles emission factors it will be possible to estimate the pollutant emissions and GHGs avoided thanks the e-logistic vehicles. Using the monitored information and the literature ones, the following indicators will be defined (Table 9.22).

Table 9.22: E-logistic indicators

Key Performance Indicator – KPI	Data	Unit measure
Energy consumed	Battery level at starting and finishing working day; Energy used per km	kWh
Avoided Emission: PM10	Drive distance; ISPRA Emission Factors	kg PM10
Avoided Emission: PM2.5	Drive distance; ISPRA Emission Factors	kg PM2.5
Avoided Emission: NOx	Drive distance; ISPRA Emission Factors	kg NOx
Avoided Emission: NMVOC	Drive distance; ISPRA Emission Factors	kg NMVOC
Avoided GHG: CO_2	Drive distance; ISPRA Emission Factors	kg CO_2
Deliveries	Daily deliveries	#/day

9.5.1 Implementation stages & timeline

The Milan e-logistic consists of four implementation stages:

- Stage 0: Monitoring plan and privacy issue resolution.
- Stage 1: Resolution of bureaucratic issue and design of the action.
- Stage 2: Assets implementation.
- Stage 3: Monitoring and evaluation of the benefits.

The previous stages are resumed in following Table 9.23.

Table 9.23: E-logistic implementation stages and timeline

Stage	Timeline	Unique Data Group
0	August 2017 – October 2018	Definition of the data to monitor, definition of the KPIs, identification and resolution of privacy issue

1	June 2018 – September 2018	Interaction between Milan Municipality, Poliedra and the e-logistic manager: action design process, purchasing of the vehicles
2	October 2018 – December 2018	Assets implementation
3	2019 - 2020	Monitoring and evaluation of the benefits

9.5.2 Data source specifications and timeline

In order to evaluate the performance of Milan e-logistic action, a set of data sources has been identified. The main source of information will be the GPS and the on-board units deployed on the e-logistic vehicles. These device will be able to collect information from the vehicles connected, allowing to monitor the main parameter of the action. To define the emission factors of the private cars which are supposed to be substituted by the e-logistic vehicles it will be used the information reported in the ISPRA database. The last available italian emission factors will be considered. In the following Table 9.24 the e-logistic data source specifications and timeline are resumed.

Table 9.24: E-logistic data source specifications and timeline

Data Source	Month																														
	Before	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
GPS & on-board unit on e-vehicles																															
ISPRA Emissions factor																															

9.5.3 Partners and responsibilities

RSE and Poliedra are responsible of the monitoring and evaluation of the e-logistic, supporting their analysis with data collected by GPS and on-board units deployed into the vehicles. RSE identifies suitable database and literature information in order to provide useful data for the benefits evaluation.

Poliedra is a consortium at Politecnico di Milano, which promotes and supports the dissemination of knowledge, by research and training activities, in the fields of integration of the environmental concerns, sustainable mobility and participation into public decision processes. Poliedra collects Milan e-logistic information which are shared by the service operator. Then, these information are shared with RSE to analyse and evaluate the e-logistic benefits.

Milan Municipality (Comune di Milano – CdM) is the coordinator of the project overall activities and is responsible of data communication and storage.

In Table 9.25 the e-logistic partners and responsibilities per data source are resumed. Milan interoperability platform (USP) is the entity responsible for the data collection, data communication and data storage.

Table 9.25: E-logistic partners and responsibilities per data source

Data source	Monitoring responsibilities							Data risk
	Create specifications	Procure	Install sensors	Collect data	Communicate data	Store data	Handle data privacy	
GPS & on-board unit on e-vehicles	RSE/Poliedra	Poliedra	ForServices	USP	USP	USP	ForServices	-
ISPRA Emissions factor	-	-	-	RSE (Collects other data)	-	-	-	-

10 CONTEXTUAL AND OTHER EVALUATION REQUIREMENTS

The Local Monitoring Programmes presented in the previous Sections, capture demonstrator and site-specific data requirements for all measures implemented by lighthouse cities. Complexity arising from links between various measures is considered and implementation constraints are taken into account in the form of collecting baseline data and setting up control groups where required. However, aside the impact oriented data collection discussed in the previous Sections, there are city wide contextual, digital social market and platform data requirements.

10.1 City Platforms

The platform is an enabling tool for smart city solutions and each lighthouse city has adopted a slightly different approach to implementing it. Each platform in the Sharing Cities programme has a uniquely structure in order to address the local city needs and constraints.

The purpose of the Lisbon USP is to aggregate data from a variety of devices and sensors related with the measures that are being implemented. Furthermore, the USP will also store and process data and will serve as a basis for visualization of information to the city and its inhabitants. The Lisbon USP has an API and Data sharing layer that supports the access and presentation of the information contained within it to the several stakeholders through tools such as API and service marketplace, dashboards, etc. A layer related to data storage and analytics will enable the maintenance of data in all its forms (structured, non-structured, geographic, pair-values, etc.) that is used and managed by the USP. This layer also offers effective and efficient mechanisms to query and retrieve data, control data flows and support analytical capabilities. Another layer of the USP is related to the data collection from city sensors and devices which enables connectivity and low level data aggregation when and if needed. In Lisbon the energy, mobility and environmental data providers interact with the USP through well-defined APIs. The platform has been implemented by Altice Labs and partners as CEIIA, EMEL, EDP Distribuição and the CML - Municipality of Lisbon provide the needed smart city IoT data to populate the USP.

For Greenwich, the platform is based on the London Datastore which is a free and open data-sharing portal, where anyone can access data relating to London. The goal of the London Datastore platform is to facilitate datasets that help understand the city and develop solutions to London's problems.

In the city of Milan two city platforms will be implemented, one provided by Siemens (Monet) and the other provided by the Municipality (USP).

The Monet platform provided by Siemens is identified by the multiservice platform Monet that allows real-time data acquisition and data aggregation for energy efficiency advanced services. Within the Sharing Cities project, Monet platform is designed indeed to optimize energy use, through advanced algorithms, of the public residential building once the photovoltaic system and the storage systems is installed in the building. However, in the context of the Sharing Cities project, the platform is also designed to monitor, store and control the third-party field devices installed in the private multi-property and in the public residential buildings to assess thermal comfort, energy consumption, the effectiveness of the retrofit activities and the outdoor weather conditions.

The Urban Sharing Platform (USP) of the city of Milan aims to provide a secure and easy to use infrastructure to enable data circulation between Service providers and data consumer by decoupling the service provider's infrastructure and data consumer's infrastructure.

The USP is built on the top of the Interoperability platform of the municipality of Milan, which has been developed by the DSIAD (IT department) of the Municipality as a way to:

- Govern data flows between different departments of the municipality and different vertical applications;
- Avoid data duplication between applications and provide an authoritative source for some data types (census data, toponymy, etc.);
- Secure data transactions;
- Facilitate external entities to access data of the Municipality in a controlled way.

The USP provides all of the above points for the Sharing Cities project and it adds some useful features like:

1. The ability for a citizen to allow or deny access to his own data stored on the service provider's systems for each data consumer;
2. Expose non-person related data coming from Service providers to other partners in the project through APIs accessed via oAuth2 authentication.

For the first use case, the USP provides some tools aimed at the citizen that wants to allow access to data (stored by service providers) related to him/her to a Data consumer. For example, a citizen that has an active subscription to the bike sharing service can allow or deny access to the data about his bike rentals to a third-party company that wants to access that data in exchange for bonus points on a mobile app.

This allows the citizen to retain control over the data related to him/her and the decision to block access to his/her data is instantly applied thanks to the Open ID Connect standard. This also decouples information about the identity of the citizen from the service provider to the data consumer since only the USP maintains information on the citizen – but not his/her data.

In the second use case, the USP gathers the data from other partners of the projects under different file format and by different means, it acquires it inside a data platform and it exposes them with APIs secured by HTTPS protocol and oAuth2 authentication. This allows an easier access to data since a third-party company must implement a single communication between its systems and the USP.

Data collected on the USP are divided in the following categories:

- Use case 1: Digital Social Market SharingMI (citizen rewarding application)
    - eBike sharing – rentals and distance on period
    - Thermal comfort, indoor air quality and energy data (electric and gas)

- Use case 2: data circulation
    - eBike sharing
    - Condominium e-Vehicle Sharing
    - Weather data
    - Smart Parking
    - e-Logistics

All the data are available to the partners of the Sharing Cities project but they can also be accessed by third parties, under an agreement between the data owner and the consumer. For example, data from Kiunsys about parking spots usage are also being used by the Synchronicity H2020 project. Figure 10.1 shows the data flow from the data providers to the data consumers.

Data Flow

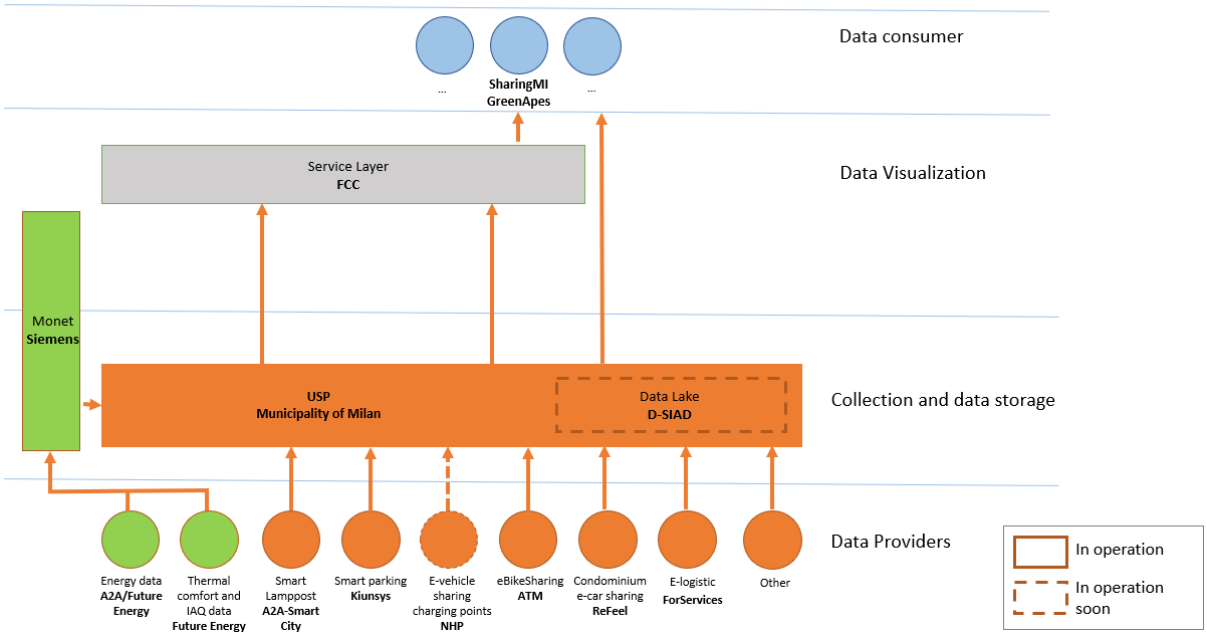


Figure 10.1: Data flow of the Milan Urban Sharing Platform (USP)

USP Municipality components

Profile manager – Citizen registration and profile management
It allows citizens to register a Sharing Cities user on the USP, and it allows or denies (default denies) access for each data consumer to the data on service providers. The authentication on the service provider platform is performed via an OIDC flows, which means that the municipality won't see the citizen's credentials on the service provider's systems.

Identity server – Citizen authentication point to log in from data consumer's app.
Similar to the profile manager, it allows the citizen to log into the app of the data consumer to identify himself. An OIDC flow is performed, so the app provider cannot access information on the user identity on the USP or service provider's systems

API gateway
It performs checks on whether the citizen allows the data consumer to access his/her data on the service provider's systems. It is also in charge of the automatic exchange and renewal of credentials for the user.

Message Broker
It allows queues management and Publish/Subscribe applications in order to guarantee the possibility of asynchronous developments for Sharing City USP and also for other internal applications.

Enterprise Service Bus
It is the middleware layer for data transformation. It is particularly useful when data are not available into the SOA architecture. Predefined and developed extended connectors (query on database, file system, script, web services) are used with standard protocols to distribute SOA API.
As an existing end-point, every ESB developed web services have to be published on API store to do API governance.

DAS
The DAS (Data Analytics Server) component is currently installed on the machine that manages the BAM services (Business Analytics Monitoring) and it represents the consol for the monitoring of each data transaction. The DAS component analyzes data in real time or in batch mode and it is necessary to control the status of the request load related to the machine request time. The DAS component is also necessary to locate and activate the error solutions.

BPS
The BPS process every activity in which the human interaction is needed: eg. the validation fluxes of services subscriptions and registration. Also, BPS manage the definition of the Throttilng Tiers for API published usage.

Container Docker Orchestration (Kubernates under Rencher)
The Municipality adopted new best practices to develop applications through the new devops vision microservices-based. This production environment allows the possibility to improve the independence among different applications and technologies.

Data lake experimental-test environment
The Municipality is working to improve the interoperability platform with a Data Lake. It will be useful to correlate data coming from different Data Sources. This is a very complex storage component and it is also dependent to privacy management. It is not available yet, but is under construction in an experimental on-premise environment.

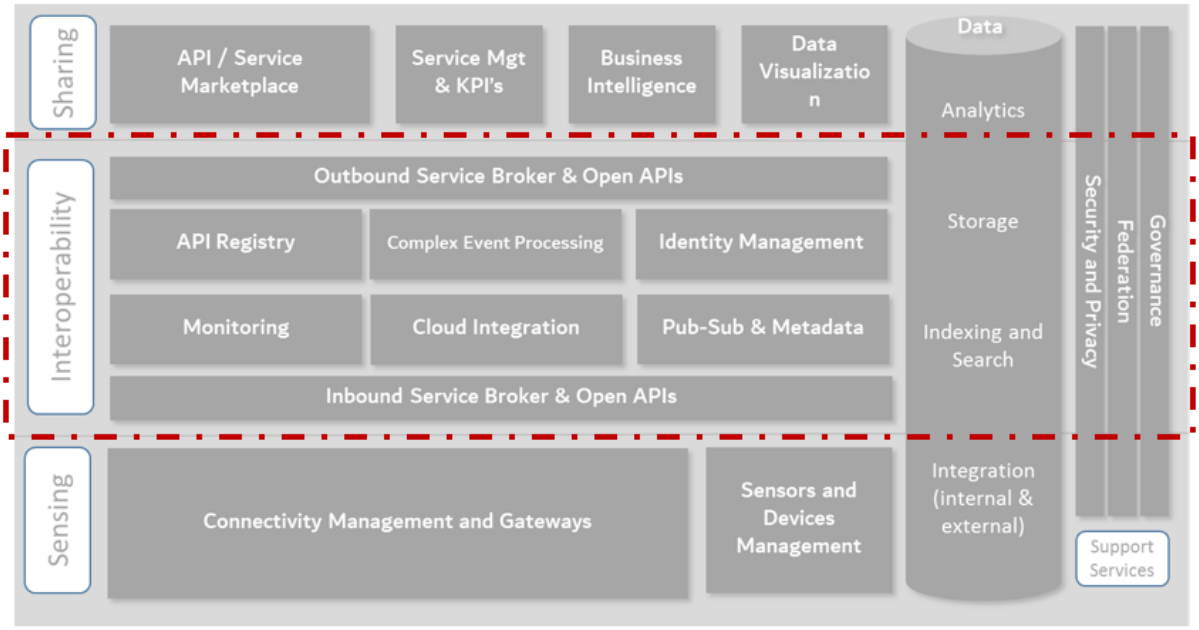


Figure 10.2: Milan USP structure and objectives

The approach and unique structure to the platform at each city will be captured at the start of its operation and will be further assessed through stakeholder interviews at the end of the Sharing Cities project evaluation period in September 2020. The evaluation will consider the ease of set up and operation, but will primarily focus on the ability of each approach to enable smart city solutions stressing its strengths and weaknesses through a SWOT analysis, while considering local city context.

10.2 Digital Social Market

The DSMs is implemented in all cities as a tool driving variation in user engagement and sustainable user behaviour. To capture the behaviour influences arising from the implementation of DSM it is essential to enable a capability to differentiate the value delivered directly from a measure to the value delivered indirectly through citizen behavioural change and the use of the local DSM. Furthermore, the nature of the DSM implemented in each city varies greatly.

The Lisbon DSM, named Sharing Lisboa, was developed based on previous insights gathered in a user research framework and design workshops involving city representatives, partners and citizens. Within the DSM the citizen will be able to voluntarily engage with local businesses taking advantage of its services and making choices based on common causes, incentives and/or reward mechanisms. This will play a crucial role in behaviour change promoting the adoption of innovative mobility options and of energy efficient behaviours at home.

The Sharing Lisboa pilot was launched in November 2018, working as an exchange of goods and services, supported by the Sharing Lisboa APP (developed by the project partner Altice Labs), bringing citizens together to support a common cause. In this pilot, the common cause are 3 schools, which will compete for the course of one academic year to win final reward. Even though the DSM has been mainly promoted among the competing schools, the school community is not the only one involved in the plot, the surrounding community, citizens and local business shops have also been incentivized to participate. Several activities and awareness campaigns have and will be promoted among students, teachers, staff and parents through a DSM agent. The DSM agent develops activities to promote the adoption of sustainable behaviours, but also supports the community by assessing their perceptions towards the DSM, challenges faced, proposals for new additions, etc.

For Greenwich the Demand Side Response trial is implemented through a smartphone app that engages residents in energy saving actions. As discussed in Section 6, electricity, temperature and humidity sensors are installed in all the participating apartments in order to rate participation and capture resident responsiveness. In this case the interaction is done in a confined environment, with good control of the participating users which simplifies the process of capturing the value delivered solely from DSM.

The City of Milan developed a digital social market (DSM) called “SharingMi” which aims to shift attitudes and behaviours at multiple levels across the city. SharingMi platform introduces a personal reward system in exchange for citizen-focused behavioural changes around the themes of mobility, energy and consumption reduction, and community participation.

By signing up to the DSM and participating in a range of sustainability-related activities, participants can earn points: for instance by changing the way they get around the city – cycling, walking or using public transport instead of using a car, by reducing the energy use or switching to renewable energy at home, joining city challenges and events or sharing green ideas and stories with the SharingMi online community.

Another way to collect points automatically is connecting “sustainable behaviours” apps and other platforms to the SharingMi app to automatically earn bonus from daily life activities; Apple Health, Strava, Energan, Spica are already available, and soon will be possible to connect more services (i.e. Bikemi – Milan’s bike sharing) through the Milan’s Urban Sharing Platform too.Points earned (called “BankoNuts”) can be redeemed to access goods and services at shops and other outlets, as a reward for having a more sustainable or greener lifestyle.

SharingMi was launched the 21st of February 2019 in the Sharing Cities Pilot Area – Porta Romana Vettabbia neighbourhood and the app is now open for the whole Milan community: in one month, almost 1.000 users signed up, 2.500 stories were shared and 8.000 “clap” were sent. SharingMi (www.sharingmi.it), powered by greenApes, is available on the Apple App Store and Google Play Store.

To isolate the behavioural changes driven by Digital Social Market, three city-wide monitoring requirements are defined:

1. Involving DSM users in a user attitudinal assessment following the evaluation principles in the LMPs presented in Sections 2 to 9.
2. Capturing the DSM app usage data to monitor citizen engagement
3. Undertaking user surveys (or incorporating questions to survey described in previous Sections) to capture directly the motivation of user behavioural changes.

10.2.1 Lisbon

In Lisbon, several data are being collected through the Sharing Lisboa APP in order to assess the APP usage, app retention rate, the products and services offered, points collected, bonus usage patterns, external accounts, user characterization. Supporting the quantitative data collected through the APP, activities with citizens and users of DSM will also be promoted in the future in order to evaluate the successfulness of DSM and gather insights on improvements and/or changes needed. These can range from focus groups, workshops, interviews. Additionally, behaviour change assessment will also be addressed, through the conduct of surveys and in-depth interviews, in which it will be possible to explore changes in patterns and adoption of more sustainable behaviours due to the active participation on Sharing Lisboa Pilot. The results from these activities will allow assessing the enablers and barriers towards DSM adoption and, consequently, improve the DSM concept and supporting APP for future implementation in the city. Given that the concept of the Lisbon DSM has been developed as a solution/tool that can be replicable and scaled up to other communities, districts, cities, countries, an assessment on the business model and operation of the Sharing Lisboa APP will also be performed.

10.3 City Context

Demonstrator specific and user specific context data requirements are included in the Local Monitoring Programmes presented in the previous Chapters. Additionally, contextual data that characterise a city and capture its features enable replication and scale up analysis of the measures developed in Sharing Cities to be undertaken (see Sharing Cities D8.6). Such contextual data are indicated in Table 10.1.

Table 10.1: Example of contextual city data (Sharing Cities D8.6)

Population and density (City/ Borough)	Metro network length
Traffic volume (Trips per day)	Park & ride sites
Freight traffic volume	Cycle & ride sites
Primary road network length	Car parking spaces available
Primary road network spatial density	Demand management schemes in place
Signal density	Real-time information provision
Types of signal control	Weather/ Time of year
Traffic control centre in place	Car ownership
Bus network length	Occupants per household
Light rail/ tram network length/ number of lines	Scheme size

It is ideal to track contextual city data throughout the project evaluation period for each city, in order to understand the context of where, how and how much value is delivered. Beyond publically available data, additional contextual data will be collected through stakeholder surveys and consultations undertaken with local authority representatives and operators.